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NOVEMBER 2013
ISSN 1030-2662 11
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QP-5512 **WAS $19.95**

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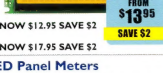

• Module size: 85(W) x 30(H) x 13(D)mm
• Viewing display area: 65(W) x 16(H)mm

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SAVE $3

Dot Matrix Alphanumeric Module

• Alphanumeric, 2 line LCD
• Module size: 85(W) x 30(H) x 13(D)mm
• Viewing display area: 65(W) x 16(H)mm

Without Backlight QP-5515
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With Backlight QP-5516
WAS $17.95 NOW $15.95 SAVE $2.00

FROM $13.95

SAVE $2

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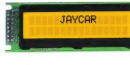

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QP-5586

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MP-3106

MP-3108

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SAVE $12

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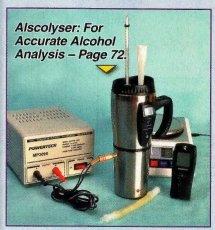

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3DAY SALE

THUR 14TH - SAT 16TH NOV 2013

Engineers File Set Second Cut

- 200mm hardened and tempered files
- Second cut: Flat, 1/2 Round, Round, Square, Triangular
- Includes carry case

~~$31.90~~

$22

(F100)

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- Ø3, 4, 5, 6, 7, 8mm
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~~$10.80~~

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(P365)

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- 4-way measuring
- Includes battery

150mm / 6"	200mm / 8"
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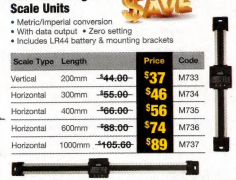
$25	**$35**
(M738)	(M739)

Aluminium Digital Scale Units

- Metric/Imperial conversion
- With data output • Zero setting
- Includes LR44 battery & mounting brackets

Scale Type	Length		Price	Code
Vertical	200mm	~~$44.00~~	$37	M733
Horizontal	300mm	~~$55.00~~	$46	M734
Horizontal	400mm	~~$66.00~~	$56	M735
Horizontal	600mm	~~$88.00~~	$74	M736
Horizontal	1000mm	~~$105.60~~	$89	M737



GSK-3 Gravity Feed Spray Gun Kit

- HVLP spray gun system
- Standard pot with 1.7mm nozzle
- Small pot with 1.0mm nozzle
- Pressure regulator with gauge

~~$99.00~~

$79

(S344)

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Imperial Set (H800)

- 9 piece
- 1/16" - 3/8"

Metric Set (H801)

- 9 piece
- 1.5 - 10mm

~~$16.50~~

$12 EACH

Metric & Imperial Drill Gauge

- Stainless steel
- 1 - 13mm
- 1/16 - 1/2"

~~$16.50~~

$12

(M988)

LCD Display Units

- Resolution: 0.01mm/0.0005"
- Metric/Imperial conversion
- Zero setting
- Includes: 2 metre scale connecting cables & 2 x AAA batteries

2-Axis DRO	3-Axis DRO
~~$108.90~~	~~$154.00~~
$92 (M731)	**$130** (M732)

AR-2 Air Hose Reel Retractable

- 20 metre x Ø10mm
- Reinforced PVC hose, 300psi
- Includes wall mount bracket

~~$110.00~~

$89

(H052)

SBD-20B Bench Drill

- 16mm drill capacity
- 2MT, 16 spindle speeds
- Swivel & tilt table
- 1hp, 240V motor

~~$319.00~~

$275

(D138)

EDBD-13 Drill Sharpener

- 3-13mm or 1/8"-1/2"
- Diamond wheel
- Split point
- 80W, 240V motor

~~$99.00~~

$79

(D070)

HM-10 Mini Mill Drill Tilting Head

- Dovetail column
- 2 speed gearbox
- Head tilts +45°
- 350W 240V motor
- Travels: (X) 225mm (Y) 100mm (Z) 190mm

~~$869.00~~

$749

(M150)

RAV2.75/36 Air Compressor

- 205 L/min pump
- 36 litre tank
- 100psi pressure
- 2.75hp, 240V motor

~~$418.00~~

$352

(C327)

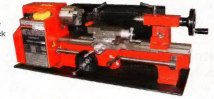
AL-30 Mini Bench Lathe

- 180 x 300mm turning capacity
- 20mm bore, 80mm 3 jaw chuck
- Electronic variable speed
- 0.25kW, 240V motor

~~$825.00~~

$749

(L194)



BS-5S Swivel Head Band Saw

- 200 x 125mm capacity
- Swivel Head 45°
- 3 blade speeds
- 1/2hp, 240V motor

~~$594.00~~

$495

(B003)

AL-336D DELUXE Centre Lathe

- 300 x 900mm capacity
- 2-Axis digital readout
- Hardened & ground bed
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- 2hp 240V motor
- Includes: 3 & 4-jaw chucks, faceplate, dead centres, work light, steadies, foot brake, splash tray & stand

~~$4,279.00~~

$3,949

(L682D)

M-52G Turret Milling Machine

- 3-Axis digital readout
- NT30 horizontal & vertical
- Swivel table left & right
- Tilting head ±90°
- 1.5kW / 2hp 415V motors
- Includes: collet chuck set, drill chuck, X-axis power feed & light
- Travels: (X) 600mm, (Y) 200mm, (Z) 340mm

~~$6,039.00~~

$5,489

(M163D)

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MX

- 0-100mm range
- 0.01mm accuracy
- 0.01mm resolution
- 4 piece

~~$160.60~~ **$136** (Q114)

22-145 Depth Micrometer

MX

- 0-50mm range
- ±0.004mm accuracy
- 100mm base
- 0.01mm resolution

~~$126.50~~ **$106** (Q145)

22-146 Depth Micrometer

MX

- 0-100mm range
- ±0.005mm accuracy
- 100mm base
- 0.01mm resolution

~~$171.60~~ **$145** (Q146)

Coolant Proof Digital Calipers

MX

Range	Resolution		Price	Code
150mm / 6"	0.01mm/0.0005"	~~$176.00~~	$149	(Q1851)
200mm / 8"	0.01mm/0.0005"	~~$198.00~~	$168	(Q1861)
300mm / 12"	0.01mm/0.0005"	~~$269.50~~	$228	(Q1871)

SAVE

1 x LED Light Telescopic Magnetic Pick up Tool

- LED lighting
- Extends from 193 - 805mm
- Includes 3 x AG13 batteries

~~$16.50~~ **$14** (M0006)

2 x LED Light Telescopic Inspection Mirror

- 2 x LED light
- 50 x 80mm mirror
- Extends from 290 - 870mm
- Includes battery

~~$19.80~~ **$16.80** (M0008)

4 Piece Telescopic Inspection Set

- Mirror extends 240 - 920mm
- Pick up tool extends 165 - 695mm
- 3.6kg fixed & swivel head
- 2.3kg fix head magnetic pick up tool

~~$19.80~~ **$16.80** (M0009)

Dead Blow Hammer

- Genuine Hickory Handle
- Fabricated Steel body
- Press fit nylon faces

~~$38.50~~ **$29** (H880)

Soft Face Hammer

- Genuine Hickory Handle
- 5 x Ø45mm Heads (Copper, Steel, Aluminium, Pu, Nylon)

~~$64.90~~ **$49** (H875)

Letter Punches

- 70mm in length

3/16" ~~$42.90~~ **$36** (P350)

5/16" ~~$53.90~~ **$45** (P354)

Number Punches

- 70mm in length

3/16" ~~$19.80~~ **$16.80** (P351)

5/16" ~~$24.20~~ **$20** (P355)

NIC Portable Video Inspection Camera

- 12.5mm camera with 1M cable
- LED lighting
- Includes 2M ext. cable, magnetic pick up, mirror tool & carry case

~~$165.00~~ **$140** (M697)

SAVE

AR-P10 Air Hose Reel Retractable

- 15M x Ø9.5mm Polyurethane hose
- Wall or ceiling mount
- 232psi / 16Bar pressure
- Includes dusting gun

~~$143.00~~ **$119** (H045)

IWB-40 Industrial Work Bench

- 1800 x 750 x 900mm
- 1000kg load capacity
- Heavy duty steel fabricated frame
- High density laminate top

~~$385.00~~ **$319** (A420)

SAVE

CS-275 MetalMaster Cold Saw Bench Model

- 90 x 50mm capacity
- Ø275 x 32mm blade
- 42rpm blade speed
- 1.3hp 240V motor

~~$1,309.00~~ **$1,089** (S816)

SUPER 12 Air Compressor

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- 58 litre tank
- 120psi pressure
- 2.2hp, 240V motor

~~$797.50~~ **$759** (C340)

IWB-40 Industrial Work Bench, Backing Panel & Storage Accessories Package

Work Bench ..... (A420)
Backing Panel ..... (A426)
4 x Single Prong Hook ..... (A440)
4 x Double Prong Hook ..... (A442)
1 x Triple Prong Hook ..... (A444)
1 x Spanner Holder ..... (A446)
1 x Screw Driver Holder ..... (A448)
Plastic Buckets .....
- 8 x (110 x 105 x 50mm) ..... (A430)
- 8 x (140 x 105 x 75mm) ..... (A432)
- 6 x (220 x 140 x 125mm) ..... (A434

PACKAGE DEAL ~~$811.80~~ **$595** (K030)

SAVE $216

ST-275 Cold Saw Stand

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- Cast iron construction
- Handle operates all functions

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Publisher's Letter

Hybrid cars may not endure

Here is a forecast: hybrid electric cars, as we presently know them, will be a rarity in a few years time! In fact, they might eventually be as rare as electric cars. Taking the last part of my statement first, electric car sales are going nowhere. While I happen to think that the Nissan Leaf is an attractive proposition (see the Publisher's Letter, October 2012), the fact is that very few have been sold either in Australia or elsewhere. And while there are many more hybrid electric cars on sale with brands like Honda, Lexus and Toyota, their overall sales are in the minority.

It is not hard to see why. Hybrid cars do not have range problems like electrics but often cost a significant amount more than equivalent petrol or diesel-engined cars and that can be more than the overall savings in fuel economy over the life of the car, say 10 years. So whether or not prospective car purchasers carefully consider the economics of a hybrid, the result is that not many are sold.

But that is not the reason for my forecast. The reason is that General Motors in the USA has just cancelled production of its Malibu hybrid for 2014. The Malibu is sold in Australia in petrol or diesel-engined form but not as a hybrid. The American hybrid version combined a 2.4-litre 4-cylinder petrol engine, electric motor and a large lithium-ion battery pack that reduces space in the boot and adds to the vehicle's weight.

It cost significantly more than the equivalent 2.5 litre petrol-engined equivalent with stop/start technology but was found to give the same fuel economy. Ergo, there was no economic reason to continue the hybrid model. Mind you, stop/start technology is a form of hybrid, sometimes referred to as "micro hybrid".

This decision by General Motors has a number of interesting consequences, apart from the potential overall direction of hybrid sales. First, large lithium-ion batteries in cars might not be a part of our motoring future. The stop/start technology in the Malibu uses two standard lead acid-batteries. One is the regular battery which starts the engine and runs all the associated electronics such as the ECU, fuel injection, ignition etc. The second battery recharges with regenerative braking (as with the battery in a full hybrid car) and powers the vehicle's systems while the engine is stopped.

So at one fell swoop, GM has eliminated the expensive lithium-ion battery, all its charging electronics, high-voltage cabling and the risk of fire. So think about this: if other car manufacturers take the same approach and elect not to use large lithium batteries in future vehicles, it may mean that continuing development of these batteries will not be rapid as it otherwise might have been. It also means that there is still a long-term future for the tried-and-true boring old lead-acid battery. Who would have thought of that?

Furthermore, if you are an investor you will possibly conclude that the future market for lithium batteries may not be as hot as once thought or that the demand for lithium (with only a few countries having a monopoly on the production of lithium ore) might not be as high and lead prices will get a lift on the London Metals Exchange.

In any case, it is probable that conventional petrol or diesel-engined cars can still get considerable improvements in fuel economy. This may not be via further improvements in engine efficiency but achieved simply by making cars lighter; they are much heavier than they were 30 years ago.

Whatever happens, it seems as though hybrid cars as we now know them might be a technological dead-end.

Leo Simpson

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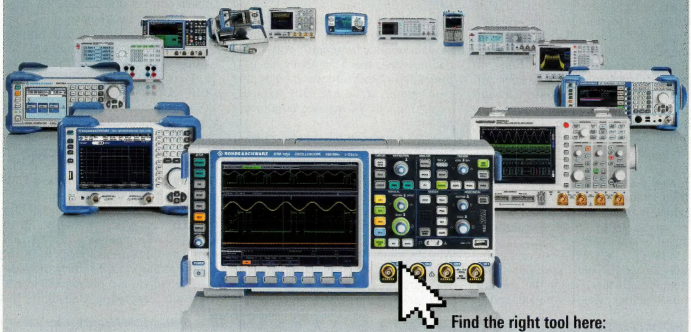

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Supplier-driven technology is not what the customer wants

It was interesting to read the Serviceman's remarks in the September 2013 issue about the apparent decline in desktop computers and the rise of tablet type devices.

Out of all of my friends – personal and small business users – only one gives the time of day to tablet technology. The others prefer desktop machines and in some cases laptops. They would not been seen dead with a tablet, especially one with an outboard keyboard and stand to make it imitate a laptop (why not use a real laptop?). They and I believe that the tablet is a most impractical way of getting work done and not very good at enabling fun either. In particular, the 'soft' keyboard drastically reduces typing speed and the touch screen rapidly becomes smeared and unsightly.

The vast majority of the hundreds of thousands of small businesses rely on their desktop machines and would not dream of trusting a tablet to meet their requirements. For one thing, a tablet is much much easier to steal or even to lose in the usual cluttered small business office.

I believe that what we are seeing here is what I call 'supplier-driven demand'. By that, I mean that the supplier decides what it wants to sell us rather than the other way round. For many years the old IBM PC standard has developed and enables original assembly and easy practical repairs at home by anyone with reasonable care and manual skills. More and more people were building their own computers and many still do. This was great irritation to profit-hungry international companies and the result has been that the consumer is driven by them more and more to buy items that are packaged in such a way that self-assembly or component level repair is not possible.

Supplier-driven technology operates with software too. When Windows 8 was announced, suddenly you could not buy any machine that was not preloaded with Windows 8, whether you wanted it or not. But without exception, all of my acquaintances hate it!

It is the same in other areas of life. Nearly every restaurant has loud and often unsuitable 'background' music pounding your ears while you are trying to enjoy a sociable meal. I have yet to find anyone who wants that. It's what the supplier decides to give, irrespective of the customer's wishes. And the appalling movement towards 'pop-up' adverts intruding on TV watching on the free-to-air service is another example of what we all don't want and the supplier determines that we will all get.

To finish on a positive note, I must congratulate your cartoonist who always manages to capture the moment with splendid detail. His depiction of Dave Thompson is excellent.

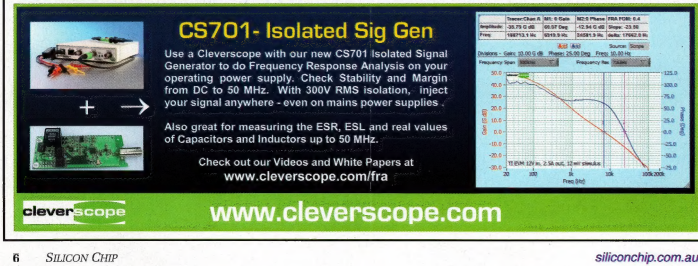
Alan Ford,
Salamander Bay, NSW.

Lithium polymer drill packs have elaborate electronics

I always enjoy SILICON CHIP articles on salvaging defunct equipment and found food for thought in the October 2013 issue "Fire Up Your Cordless Drill" article. Ironically, I bought two 24V DSE battery packs for $3 each when DSE closed out the line a few years ago, then stripped them down and used the cells to revive some of my collection of old cordless drills, including two Black & Decker 7.2V units which are decades old.

Later, I was given a Ryobi lithium drill kit, comprising two 18V 1.4Ah batteries, a fast charger and a 2-speed drill. I find this unit superior to any of the nicad-based units I have owned.

Included are two photos, obviously not to the same scale. One shows the



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Mailbag: continued

Query on solar panel regulator

I am writing about the the 2N3055 power transistor used as in the 72V Solar Panel Battery Charger/Regulator, as featured in the September 2013 issue. The picture of the 12/24V regulator intrigued me because it's a long while since I've seen a 2N3055 used in anything. Unfortunately, in this case, I think it's being misused.

The article says a 2N3055 was chosen because "it does have a high voltage rating for this mode of operation – 95V". That didn't match my memory and my trusty Motorola Power Device Data book agreed. According to the specifications in the data book, the maximum Vceo is 60V – well below the 95V mentioned in the article.

Looking at the other potentially relevant voltage rating, Vcb is 100V – but that's not relevant because the emitter is more negative than the base in this application. Vcer is 70V but that's still on the low side and there's no low-impedance base-emitter path so it's not applicable.

Actually, I'm surprised that the primary side switcher uses a linear series regulator. While this is simple, it also the most wasteful of power. It would seem more efficient to run the switcher off a second rectifier on the 12V windings, with a series regulator for bootstrapping only. In either case, something like a TIP31C would seen a better choice as a pass transistor.

Peter Jeremy,
Killarney Heights, NSW.

Comment: there is no doubt that the 2N3055 is a very old transistor. Evidently, Oatley Electronics has reasonable stocks of this device and decided it would be suitable for the design.

Furthermore, while a switching regulator circuit would have been more efficient, the current drain to the SG3535 is quite low, so the overall circuit efficiency is not reduced by much.

The transistor ratings in the Philips data show Vcbo (open emitter) as 100V and Vce as 70V. That is with a 100Ω resistance between base and emitter. So the voltage rating is closer to 70V than the 95V figure quoted in the article.

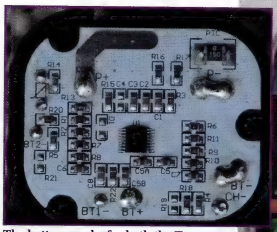
However, the circuit on Q1 has it start to conduct to clamp the emitter at 0.7V below the base that is at 10V. The voltage at the collector is going to be the solar panel voltage minus the drop across the 1.2kΩ 5W resistor.

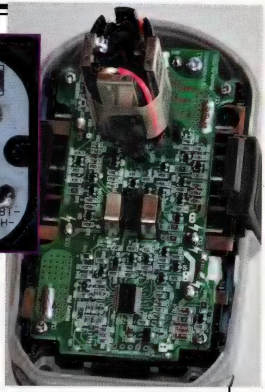
Assuming a supply current of more than 10mA, the voltage between collector and emitter is the panel voltage minus the emitter voltage of 9.3V and the 12V across the 1.2kΩ resistor. So the transistor should be just safe to use when the panel has 90V across its terminals.

internals of a Ryobi 18V 1.4Ah 5-cell lithium battery pack and the other, the controller in a much more compact Taurus 3-cell 10.8V 1.3Ah pack. The Taurus, which I bought more recently for about $70 from Aldi, came with two battery packs.

As you can see from the photos, the battery packs include elaborate electronics. So far as I can tell from the markings on the 16-pin chip visible on the Taurus controller, it is an S-8254A, described in a Seiko data-sheet as "a protection IC for 3-serial or 4-serial-cell lithium-ion/lithium polymer rechargeable batteries". The 28-pin chip on the Ryobi controller is marked "HA1930" and is possibly an OEM version of a PIC16F88N-series controller. Both boards are doubled-sided, with what are probably power switching components on the reverse; the Ryobi unit even has an aluminium heatsink.

The Taurus battery has only three external connectors (not visible in the photo), whereas the Ryobi has five (all visible in the photo) though only four are used by the charger.





The battery packs for both the Taurus (above) and Ryobi (right) drill kits contain eleborate electronic circuitry to control charging.

I have not attempted to reverse engineer the circuits but infer that the cell balancing is done by the battery packs themselves. In the case of the Ryobi, the charger contains an elaborate electronics module with a switchmode power supply and has several status LEDs. I suspect that there might be a serial data link between the Ryobi battery and the charger.

The Ryobi drill has only two con-

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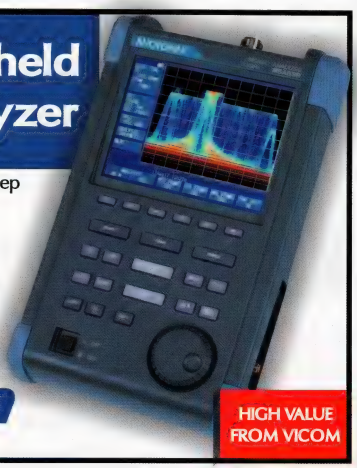

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Mailbag: continued

nectors to the battery pack. The drill does not behave like any of the old nicad-powered units I have used. It does not gradually 'grind to a halt' under load when the charge is low. Instead, it simply stops, undoubtedly due to the protection built into the battery pack.

Similarly, even though it has quite a lot of torque, if very heavily loaded with a full charge, it does not labour much like nicad-powered drills. Once again, it just stops.

All of this is consistent with all I have read about lithium cells, including articles in SILICON CHIP. They cannot be mistreated as nicads can without serious consequences, so manufacturers using them in consumer products, whether computers, phones, or cordless drills, have to build-in 'smarts' to manage the cells.

Suppliers of packs for RC model aircraft take a riskier approach, presumably because every gram counts, and so omit the controller in favour of a lighter 'multi-connector' for an external charge controller. One assumes they get away with this because the model aircraft community generally is well informed about the issues and prioritises light weight over reliability and even safety.

So I infer that your efforts to 'scour the shelves at a couple of major hardware chains' looking for a charger multi-connector have been based on a wrong assumption. Of course, my selection of two examples from the many brands on the market does not prove anything but it does imply that the design paradigm for lithium battery packs for cordless drills is different to that for nicads despite their similar external appearance, especially given that the examples are not expensive 'up-market' brands.

Peter Bennett,
Macarthur, ACT.

Software fix for 12-digit frequency counter

There is a small problem with the 12-Digit 2.5GHz Frequency Counter (December 2012 & January 2013) that I have recently constructed. While checking a 77.5kHz signal, I noticed that the last digit (LSD) was cycling up and down and sometimes the second last digit was also changing.

Looking at the data-sheet for IC14 (74AC163), when the Parallel Enable (PE) pin (pin 9) is pulled low, a clock pulse is still required to load zeros into the counter. For input frequencies above 2MHz this will probably always occur but for low frequencies this will be random, and so often the LSD will not be reset and the new count will be added to the least significant digit.

A software solution is to temporarily enable the 1MHz period count, to clock IC14. This can be done by setting the -FREQ/PERIOD line high, and also the SEL I/P CHAN

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A low (so it does not interfere) for about 1µs. I have not checked what happens with the Channel B input for frequencies above 100MHz.

I added some code to the firmware which was easy to do (even though I do not know PIC assembler well), since your code is very well documented. The codes seems to work for me.

A better solution would probably be to add some extra gating so that the Reset Decades 1&2 signal is routed to the -SR pin, pin 1.

Peter Urban,
Seven Hills, NSW.

Jim Rowe comments: Peter Urban is correct – the least significant digit will tend to have increased 'bobble' when measuring very low frequencies. I did miss that note in the 74AC163 datasheet about the PE-bar pin not actually performing a parallel load 'reset' when it's pulsed low – it only prepares the chip to do the parallel loading/resetting on the arrival of the next clock pulse (a hidden trap for the unwary.)

My thanks to Peter Urban for finding this little bug and also for working out a way to compensate for it by putting some extra code in the firmware. This is obviously the way to go, because the alternative of adding an extra chip would be messy.

ADS-B antenna amplifier should be workable

I have been following your series on getting the best out of ADS-B reception and note that you have correctly concluded that the higher and clearer the antenna is located, the more likely it will pick up the widest possible range of aircraft transmissions. Of course, having the antenna elevated means that there is going to be some significant loss in the feed line, because of its length, even if you use high quality coax.

A low-cost solution could be to insert a common "satellite line amplifier" into the cable and a compatible power inserter at the receiver end. With usually about +20dB of gain, they do a good job of keeping the 1080MHz signal levels up in the usable range. There is some increase in the noise level though, as these are fairly low cost devices.

Eric Fien
Mt Kembla, Vic.

Comments about Bush radio features

I was very interested to read the review by Leo Simpson in the September 2013 issue on the modern Bush TR82DAB radio and also the article by Ian Batty in the Vintage Radio column about the classic Bush TR82C Mk2 model. Concerning Mr Simpson's review, I would just make the following points:

(1) On page 29, it is stated ". . . this TR82DAB model is the only DAB+ radio available in Australia which features AM as well as FM stereo reception . . ." I don't think this is quite correct. There is another radio selling in Australia which also has reception

Mailbag: continued

Driving economically may hold up traffic

I read and enjoyed the evaluation of emerging consumer technology in the Head-Up Display (HUD) article and Publisher's Letter in the October 2013 issue.

As the article indicated, while it's a good start, it's more of a technical novelty at this time rather than a necessary practical solution. As a professional technologist and experimenter of over 40 years, with a particular interest in automotive and embedded electronics, I have to wonder at times at the use of technology for technology's sake.

To champion the use of a HUD, so as not to have to glance at the speedo, may have its place in a fighter aircraft cockpit where the pilot's skills and airspace are not in question but it would not seem to have the same equivalence in the driving seat of a motor vehicle on a crowded road.

Learner drivers are taught to observe information from multiple sources to ensure that they are aware of all that is going on around them – left/right mirrors, rear view mirror, blind spots and instruments, as well as the view out the front window.

Yet how often do you see drivers not attending to these tasks, totally unaware of their surroundings? How often do you see drivers travelling at excessive speed or too close to another vehicle? Is it really too difficult to maintain your awareness of your surroundings and speed without fixating on one instrument – the speedo? Too many drivers have little enough skill as it is, without suggesting that technology can make up for that lack of skill.

The car manufacturers and the safety experts push and applaud technology as the solution to our road safety problems, yet the biggest problem cannot be solved by technology: The Nut Behind The Wheel.

If you add the use of technology to "improve" fuel economy/driving practices, then you also need to address the issue that you are but one driver on the road.

I think also that if you were to research a technology article on traffic controls and traffic flows, you would find that road-sensor-actuated traffic signals actually require a vehicle to trigger them, which is not going to happen when drivers slow prematurely to "save fuel".

The premature slowing of vehicles approaching controlled intersection also interferes with other vehicles entering turning lanes and their respective separate road sensors. This then becomes an example of technology (traffic controls) being defeated by driver self-interest.

I acknowledge that the Editor, in advocating reasonable and economical driving practices, is not advocating self-interested driving techniques and nor do I. Unfortunately, a significant proportion of drivers are not technology aware or skilled enough in the first place to make use of added technology without impacting negatively on other road users.

Gary Brewer,
Croydon Hills, Vic.

on all three bands – the Sangean DPR-45. It has a recommended retail price of $219.00, and is currently available from some of the larger electrical appliance stores, and new from eBay at less than this amount. This radio may be checked out on the internet at: www.sangean.com.au/images/PDF/digital_flyers/DPR-45.pdf

(2) At the top of the same page, the header says ". . . classic 1960s styling . . ." Mr Batty's article indicates that the first model, the TR82, came out in 1959 (although his article is about the later TR82C Mk2 from the early 1960s). If the original 1959 mouldings for the case have been used for both the TR82C MK2 and the modern DAB+ radio, wouldn't the header be more accurate if it read ". . . classic 1950s styling . . ."?

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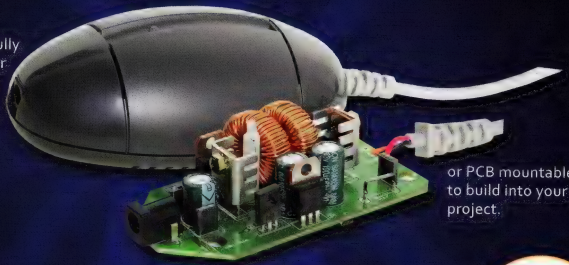

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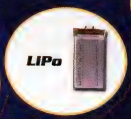

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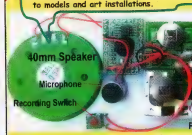

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Mailbag: continued

Note of appreciation for SILICON CHIP

This is just a little note of appreciation for your magazine. I subscribed to *Electronics Australia* in the early 1970s then put it aside and came back to SILICON CHIP a few years ago.

I enjoy the eclectic mix of articles. Practical articles like the recent ones about lithium batteries, digital television, radio microphones, and SD memory cards, help to fill in knowledge about common technology.

Also I like the Vintage Radio section. It reminds me of my days building valve equipment in the 1960s.

The construction projects are interesting, even if you don't build them, for what you can learn about current technology in chips, circuit techniques and construction methods.

Paul Howson,
Warwick, Qld.

I enjoy reading SILICON CHIP every month and over the years have built several of your projects. Keep up the good work.

Rod Peeler,
Hampton Park, Vic.

Comments on GPS timebase accuracy

I refer to the letter and comments on the accuracy of your GPS Timebase on page 4 of the April 2013 issue.

It's not surprising that you achieved agreement between your GPS-Based Frequency Reference and the 12-digit counter driven by a GPS timebase. I looked at the revised online circuit diagram (September 2011) and concluded that the Frequency Reference would slavishly follow the same deviations as the GPS timebase. I have not read the original article, as it was published before I became a subscriber, so I do not know what range of 'pull' the ladder DAC was expected to exert on the reference crystal.

For argument's sake, I am assuming it is in the order of 1ppm as I believe the full range of pull on a crystal can be typically 20ppm up to 100ppm. This means a single step of the DAC will change the frequency by about four parts in 10^9 which is pretty crude. I think the 10µF capacitor and 3MΩ resistor are supposed to smooth this but I cannot see how. The output of IC13a through the 1kΩ resistor would totally swamp any effect they may have so I think they are useless or there's an error in the circuit diagram.

My conclusion is that the difference of three parts in 10^{10} was not an absolute measure, just a difference between two sources of unknown accuracy over a long period of time.

My reading on errors in GPS is that it could be typically five metres and up to 15 metres in error. The most likely culprit here is ionospheric conditions which change all the time. As we do not have access to the equivalent of a WAAS signal, there is no way to know if this is happening. I read in the specifications of one GPS module that the 1pps GPS signal is only as good as the GPS position calculation. The satellites cruise at 20000km above Earth

so five metres is nearly three parts in 10^7. Admittedly, using a 1000-second measurement period would reduce this to three parts in 10^{10} but this is an artificial way to claim better accuracy.

No-one wants to wait over a quarter of an hour for a reading. To take it to extremes, why not measure over 14 days (if the counter allowed) and claim an accuracy of three parts in 10^{13}? No, what is required is a highly accurate and stable 1pps signal where the length of each second is accurate. As an aside, what happens to the GPS timebase if something happens to the signal during or at the end of measurement? For example, a passing aircraft may reflect or mask the signal for a second or two. Does it 'lose' a pulse? That would definitely be bad for accuracy.

An accuracy approaching one part in 10^{11} could be achieved in a 1pps signal and I suggest it would make the counter a whole lot more useful. The main reason for counting over 1000 seconds is to mitigate the effect of the GPS jitter. How much better if you could feed in, for example, a 144MHz signal and read it off accurate to the last Hertz in one second? The GPS-based Frequency Reference is a good starting point; all that is needed is to modify it suitably.

In fact, it can be simplified somewhat by adding a second CPU equivalent to the PIC16F628A to do much of the hard work. If the GPS unit's 1pps signal were fed to RB0 and RB3 reconfigured as a pulse width modulated (PWM) output fed through a filter to pin 3 of IC13a, then IC5-IC9 and IC12 are unnecessary, as software can replace them.

Although the PWM provides only 10 bits of accuracy, suitable dithering of the signal over a 1-second time-frame will provide a correction signal orders of magnitude better than provided by the ladder DAC. Since the CPU is being driven by the 10MHz crystal, it can utilise an internal timer and software to compare the differences between the GPS and the crystal. However, some circuitry may be required to derive the 1pps output (I am not sure if the CPU could produce a signal of the required quality).

To achieve the desired accuracy, the reference would need to be running for a few days at most. I think anyone who was interested in such a piece of equipment would expect to leave it running all the time, perhaps with battery back-up. In that time, ionospheric errors will average out and the crystal will settle down. The CPU would have the capability in software to average over a time period of days rather than seconds. Also, the CPU could measure the crystal frequency drift that occurs with ageing, and could provide a progressive first order correction along the way.

I once worked in a laboratory where our very expensive 5MHz crystal drifted about three parts in 10^{12} per week, but after a 3-month bedding in period it was very consistent, so it was possible to apply a correction if needed. We measured the frequency against an atomic standard each week and applied a manual correction to the control voltage each day. This task can now be offloaded to the CPU.

In case the CPU is not up to all the additional tasks required, there are plenty of more powerful alternatives out there. I think I see a project coming up.

Alan Cashin,
Islington, NSW. SC

Raspberry Pi XBMC Solution from element14

by Ross Tester

In the May 2013 issue of SILICON CHIP, we introduced the Raspberry Pi. Here we go one step further and add element14's XBMC solution, which allows you to build a low cost, high performance media centre by connecting up your Pi, plugging in to your TV and adding your own content.

If you haven't heard of the Raspberry Pi, welcome back from your trip to outer Mongolia or Mars (although we're not sure you didn't have your eyes and ears tightly closed while you were there!).

This tiny (85 x 56mm) single-board computer really is setting the world abuzz, if not on fire!

If you want to know more, we suggest you refer to that May article, which explains in some detail how to set up and use the Raspberry Pi.

XBMC

Some weeks ago, element14 suggested we might like to have a look at their packaged XBMC solution. Now before we get too far ahead of ourselves, the name: XBMC. It was originally created as a media centre application for the original Xbox game console, named "Xbox Media Centre" but is today officially available, under the name "XBMC" as a native application for Android, Linux, BSD, Mac OS X, iOS, and Microsoft Windows operating systems.

It is the Linux iteration that we are interested in here; the name given to this interface is Raspbmc, or Raspberry Pi Media Centre.

If you're still none the wiser, perhaps you've heard of Apple TV? Raspberry Pi/XBMC is quite similar and although it is not quite as fast as Apple TV2, it is significantly cheaper (and you don't have to jailbreak it!).

It is capable of 1080p video, though a lot of reports suggest 720p is a lot more reliable.

What can it do?

A Media Centre, as its name suggests, brings all your various media together into one, easily manageable collection – then makes the selection and playback of that media much simpler than selecting it manually.

What media? Basically, anything that you either have in your collection or anything you want to add to your collection. Naturally, that normally means videos (movies, tv programs, action cam clips and so

on) and music (whether downloaded or ripped from your CD collection).

Many people prefer to place a copy of their original music or DVDs on a hard disk to preclude damage to the CD, DVD etc – and this is precisely what XBMC is superb at managing. The legalities of doing this are a bit grey but providing you own the original (ie, it's not a pirate copy) we don't imagine there could be too much difficulty.

Downloading TV programs and other video sources are not quite so legally vague – all we'll say is that if you do have lots of video and audio files, you need something like XBMC to manage it!

What's in the box?

You'll receive a 4GB class 4 SD card (with Raspbmc preloaded onto it), a 3m Cat5e Ethernet cable (to connect the Raspberry Pi module to your network), a 1m HDMI cable (to connect the module to your TV set via a spare HDMI input) and last (but certainly not least!) a nifty little Wireless Keypad and Touchpad, claimed to be the world's smallest! All of this has a retail price of $69.30, with free delivery.

Note that this does not include the Raspberry Pi itself – if you don't have one already, you can order it at the same time from element14 for $41.85 (512MB, Model B) or $53.90 with an 8GB SD card pre-installed with NOOBS. The earlier 256MB Model A is much cheaper ($29.70) but we would strongly suggest you choose the newer, more powerful Pi for use with XBMC.

No HDMI on your TV?

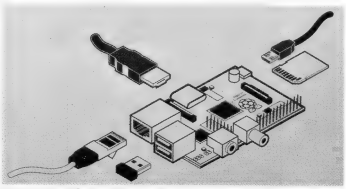
You don't *have* to use the HDMI output (especially if you don't have an HDMI input to your TV set!) because the Pi module also has a composite video (RCA) output and audio via a 3.5mm stereo jack socket. However, no cables are supplied for these outputs (most hobbyists will have a junk box full of 'em!).

Other software is available as (typically free) downloads should you need it but what's in the box is usually enough to connect you to your Raspberry Pi module and get you on your merry way.

We are assuming that you have already played with your Raspberry Pi module enough to have a basic understanding of how it works and what it does. Implicit in this is that you also have a 5V, 700mA (or greater) USB-type power supply. A lot of people power the Pi from their TV set USB output, as these generally can supply up to 1A.

As video is more demanding than audio or other files, you need to use fast, high quality media. Class 6 SD cards are minimum; class 10 would be better. Similar comments apply to any flash memory sticks – don't expect a $2 special to perform very well (it may not even work at all!) – go for known, high performance brands

If you want to connect a USB hard drive to the Pi for large data storage, it too should be pretty high specced and will need to have its own supply, as the Pi module probably cannot deliver enough power to run one.



Setup is simple: just plug in the leads, insert the SD card and WiFi dongle and apply power.

First time setup

Even if you haven't played with the Raspberry Pi before, first time setup is a breeze. Once connected (and that's dead easy) the Raspberry Pi XBMC does just about everything for you.

First, connect the Raspberry Pi module via its two (supplied) cables to an HDMI (TV) input and to your home network. As mentioned earlier, if you don't have a TV with HDMI, you'll need to use composite video out (RCA socket) and audio out (3.5mm socket) instead.

Next, plug the supplied SD card into its socket on the underside of the PCB and the wireless keyboard dongle into one of the USB ports on the board. Note that the mini keyboard needs charging before it will work (a USB cable is supplied with the keyboard) and don't forget that there is a power switch on the mini keyboard which must of course be turned on! The mini keyboard gives you both a "QWERTY" keyboard (albeit, one for micro-sized fingers) along with a trackpad mouse which

And here's the setup, ready to run. The Raspberry Pi has a power lead on the left, the HDMI cable emerging from the bottom, an ethernet cable on the right and the wireless keyboard dongle fitted to one of the two USB ports top right. The SD card containing the firmware plugs into a socket underneath at left. Once you get this far, apply power and after some delay, you should see the user interface screen (below). This is an actual "live" (ie, off-TV) shot.

also has a "wheel" function.

Finally, connect power. The Raspberry Pi automatically boots (the firmware is on the SD card) and you should see the "Raspbmc" logo on your TV screen. The first time you do this takes a little time as it has to set up the system; subsequent boots should be quicker.

The Raspbmc screen

On your TV you should see a "user interface" screen as shown at right. This will allow you to browse your videos, music and other media – once they are added, of course.

From here on in, it's pretty self explanatory. For instance, if you want to add videos/movies/etc, you'd click on <Videos>, <Files>, <Add Videos>, <Browse> and you should now see all the videos on either your SD card or USB hard disk drive if you've fitted one.

Note our earlier comments about USB hard disks – the Raspberry Pi doesn't have enough power available to run a hard disk – you need one which has its own power supply.

If you want to add audio files, it's the same process but obviously you would select <Audio> instead of <Videos>.

If your files are stored somewhere else on your home network, Raspbmc can find them for you and manage them in the same way – you'd select <Windows Network (SMB)> and go from there.

Internet services

Assuming you have an internet service (broadband, obviously), by selecting <Video Add Ons> Rasbpmc allows you to install popular add-ons – YouTube, for example. There's a range of other services available but not all will work in Australia without some mucking around. BBC iPlayer, for example, is a great service but it's restricted to the UK. However, there are work-arounds which fool iPlayer into believing you're firmly ensconced within the sound of Bow Bells.

See our article "Cheap and Cheerful Smart TV" in the July 2013 issue of SILICON CHIP for more details.

You'll also be able to access weather, RSS feeds, news services . . . in fact, the sky is literally the limit.

Conclusion

We have barely scratched the surface of the Raspberry Pi/XBMC. The more you use it, the more you'll find it can do. And when you're not using it for XBMC, you can learn more about this popular little computer.

Despite the fact that the XBMC kit has little documentation, there are several excellent "startup" guides on the net which go into much more detail than we've had space for here. And given the unbelievable popularity of the Pi around the world, you'll find an enormous amount of information available for the asking. There are many Raspberry Pi forums including some which specialise in XBMC. Your best friend Google will steer you in the right direction.

There's also a lot – ***a lot*** – of Raspberry Pi add-ons available to make your Pi experience even more rewarding. Some of these are available from element14 (**www.element14.com**) and some are from other suppliers. Again, Google Raspberry Pi. SC

The first time you apply power and run Raspmc (it's on the SD card supplied with the XBMC kit and loads automatically) from there on, it's up to you just how far you take your Raspberry Pi XBMC. If you have a large collection of videos and/or audio files (or even grandpop's 5,000 slides of his 1960 European Vacation to scan and store!) you're probably going to want to add a USB hard disk or large flash drive to hold it all.

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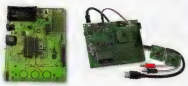

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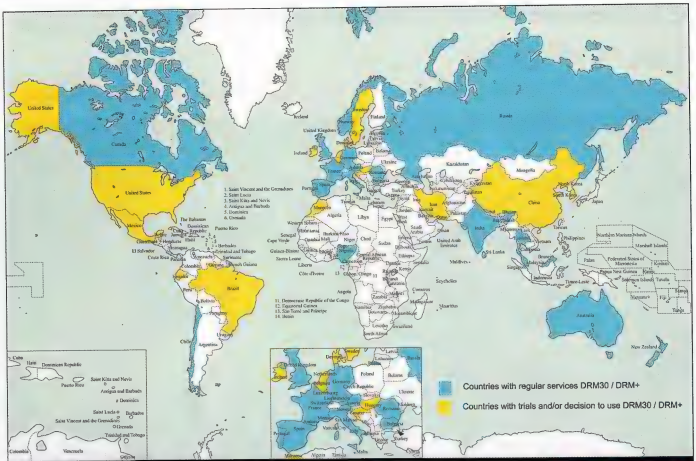


Fig.1 (above): the blue areas of this map show the countries that are currently broadcasting regular DRM services, while those countries that are either conducting trials or have decided to become involved in DRM are shown in yellow.

DRM Digital Radio

What It's All About . . .

You have heard about DAB+ digital radio which has about the same line-of-sight range as FM transmissions. Now there's DRM which stands for "Digital Radio Mondiale". It's the new international standard for long-distance digital radio broadcasting on the long wave, medium wave, shortwave and VHF bands. In this article, we explain the basics of DRM and how it works. And elsewhere in this issue we tell you how to receive and decode DRM signals using your PC with our SiDRADIO.

By JIM ROWE

DRM (Digital Radio Mondiale) TRANSMISSION MODES, OPTIONS & CHARACTERISTICS						
VARIANT	MODE	TYPICAL USES	SIGNAL BANDWIDTH OPTIONS (kHz)	MSC QAM CODING OPTIONS	APPROXIMATE AVAILABLE BIT RATE	
					MAX. ROBUSTNESS	MIN. ROBUSTNESS
DRM30	A	LF & MF GROUND-WAVE, 26MHz BAND LINE-OF-SIGHT	(4.5, 5)	16-QAM	13.1 kb/s	16.4 kb/s
			9	64-QAM	19.7 kb/s	30.9 kb/s
			10	16-QAM	14.8 kb/s	18.4 kb/s
			(18, 20)	64-QAM	22.1 kb/s	34.8 kb/s
	B	MF & HF TRANSMISSION ON SKY-WAVE	(4.5, 5)	16-QAM	10.2 kb/s	12.8 kb/s
			9	64-QAM	15.3 kb/s	24.1 kb/s
			10	16-QAM	11.6 kb/s	14.6 kb/s
			(18, 20)	64-QAM	17.5 kb/s	27.4 kb/s
	C	DIFFICULT SKY-WAVE CHANNELS ON HF	10	16-QAM	9.2 kb/s	11.5 kb/s
				64-QAM	13.8 kb/s	21.6 kb/s
			20	16-QAM	19.3 kb/s	24.1 kb/s
				64-QAM	28.9 kb/s	45.5 kb/s
	D	NVIS SKY-WAVE (HIGHEST DOPPLER & DELAY SPREAD)	10	16-QAM	6.1 kb/s	7.6 kb/s
				64-QAM	9.1 kb/s	14.4 kb/s
			20	16-QAM	13 kb/s	16.2 kb/s
				64-QAM	19.5 kb/s	30.6 kb/s
DRM+	E	VHF TRANSMISSIONS IN BANDS ABOVE 30MHz	100	16-QAM	99.4 kb/s	186.3 kb/s
				4-QAM	37.2 kb/s	74.5 kb/s

Fig.2: DRM transmission modes, coding options and available bit rates. The 'main service channel' or 'MSC' (ie, the digital audio channel itself) of both DRM30 and DRM+ signals is generally modulated onto the RF subcarriers using quadrature amplitude modulation (QAM).

DRM HAS BEEN developed and is being promoted by the DRM Consortium, an international not-for-profit group which has over 93 member organisations in 39 countries. Many of the members are broadcasters but there are also many transmitter and receiver manufacturers, as well as broadcasting standards bodies.

The aim of the Consortium is to support and spread a digital broadcasting system suitable for use in all of the frequency bands up to VHF band III. You can find more about the DRM Consortium at www.drm.org

By the way, 'mondiale' means 'world wide' in French and Italian.

There are two main variants of DRM. First, there is DRM30, intended specifically for use on the traditional low, medium and high-frequency (shortwave) bands below 30MHz and the existing AM broadcasting channels within them. The other variant is DRM+, intended for use at VHF and in particular for FM broadcast Band II (87.5-108MHz).

Both variants use orthogonal frequency division multiplexing (OFDM) for reliable transmission and digital compression/coding for high spectrum efficiency. They can also carry digital data services along with the audio signals, such as station names, time, date and program information.

DRM30, DRM+ and DAB+

So where does DAB+ fit into this proposed DRM future? After all, we've now had digital radio broadcasting in Australia for the last four years or so using the DAB+ system but it's been confined to the larger cities and their suburbs.

There is no definitive answer as yet. It looks as if DRM30 is likely to become the world standard for digital radio broadcasting below 30MHz but DRM+ might well end up competing with DAB+ in the VHF and UHF bands. This is quite possible, because DRM+ is being promoted as a replacement for analog FM broadcasting in the 88-108MHz band while DAB+ is now firmly established in the 174-240MHz band (Band III).

We'll just have to wait and see what happens. One possibility is that receivers able to receive both DAB+ and DRM+ may become popular.

So what's the difference between DRM and DAB+? In fact, there are many similarities and not many differences. Both are digital audio broadcasting systems which use OFDM – the technique of modulating digital information on an array of closely-spaced RF subcarriers, instead of a single main carrier.

This is exactly the same kind of modulation used in DVB-T television, wireless LANs (IEEE 802.11a, g & n) and ADSL broadband over copper telephone lines. Each carrier is 90° out of phase (ie, orthogonal) with its neighbours on either side, to reduce mutual interference. And both DRM and DAB+ use a digital signal processing (DSP) coding/compression algorithm known as MPEG-4 High Efficiency Advanced Audio Coding v2 (HE-AAC v2) to process the digital audio samples for modulation of the multiple-frequency OFDM subcarriers.

The differences between the two systems are rather more subtle. DAB+ appears to use 1536 subcarriers transmitted in parallel, each with a bandwidth of 1kHz and spaced apart by the same figure. This gives a DAB+ subcarrier 'block' a total bandwidth of 1.537MHz. However, since this block can convey as many as 16 different high quality digital audio signals as well as their accompanying data, DAB+ signals tend to be grouped together in 'multiplexes' whereby the separate broadcasting signals are effectively mixed together into a single DAB+ subcarrier block for transmission. The individual signals are separated again in the receiver.

In contrast with this DAB+ multiplexing system, DRM30 has been designed specifically for use in the AM bands below 30MHz. As a result, its individual broadcasting signals are generally encoded so that each one fits neatly into the 9kHz or 10kHz channels traditionally used in this part of the spectrum. DRM30 is also capable of encoding into 18kHz or 20kHz channels, for higher quality or greater reliability.

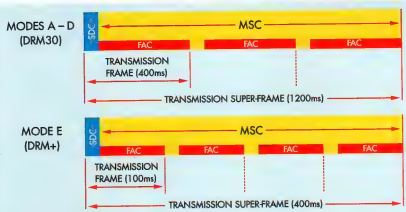


Fig.3: how the three data channels are grouped into the data stream transmitted in DRM30 and DRM+ digital broadcasting. DRM30 modes group the data into 1200ms-long 'super frames' consisting of three frames 400ms long, while DRM+ groups the data into 400ms-long super frames each consisting of four frames 100ms long.

Similarly, DRM+ is designed to encode single mono, stereo or surround sound signals into a channel 100kHz wide, making it compatible with the FM channel structure used in the Band II VHF spectrum.

Modes, bandwidth & QAM options

To achieve the desired level of performance on the bands below 30MHz, DRM30 broadcasters use four different encoding modes designated "A", "B", "C" and "D", while DRM+ broadcasters use a fifth encoding mode designated (you guessed it!) "E".

Each of these modes is designed to achieve the best performance in a different broadcasting application, as you can see in the table of Fig.2. You'll also note from this table that the 'main service channel' or 'MSC' (ie, the digital audio channel itself) of both DRM30 and DRM+ signals is generally modulated onto the RF subcarriers using the quadrature amplitude modulation (QAM) system.

DRM30 broadcasters have the option of choosing either 64-QAM or 16-QAM coding, while DRM+ broadcasters can use either 16-QAM or 4-QAM.

The idea behind this is that 64-QAM can encode 64 points in its amplitude/phase or 'I/Q' 'constellation', allowing the subcarriers to carry six bits of information in each digital sample or 'symbol' and hence a higher total bit rate. However, the 64 points in a 64-QAM constellation are inevitably closer together in both amplitude and phase, making it more susceptible to data corruption due to noise and interference.

By contrast, 16-QAM has only 16 points in its amplitude/phase constellation, so the individual points are further apart – making it more suitable for noisy conditions, even though it can encode only four bits of information in each digital symbol (and hence a lower overall bit rate).

The 4-QAM option available for DRM+ takes this trade-off even further, allowing it to encode only two bits per digital symbol and hence a lower overall bit rate again. But that's not really too much of a problem when DRM+ signals are encoded into a 100kHz wide channel, as you can see from Fig.2.

CURRENT DRM30 TRANSMISSIONS IN THE SOUTH PACIFIC

TIME (UTC)	TIME (EAST)	FREQUENCY	BROADCASTER	TARGET AREA
04:59 – 06:50	14:59 – 16:50	11675 kHz	RADIO NEW ZEALAND	PACIFIC
06:51 – 07:58	16:51 – 17:58	9890 kHz	RADIO NEW ZEALAND	TONGA
07:59 – 10:58	17:59 – 20:58	9890 kHz	RADIO NEW ZEALAND	PACIFIC
10:59 – 12:00	20:59 – 22:00	9890 kHz	RADIO NEW ZEALAND	PACIFIC
15:51 – 17:45	01:51 – 03:45	7330 kHz	RADIO NEW ZEALAND	COOK ISLANDS
17:46 – 18:35	03:46 – 04:35	7330 kHz	RADIO NEW ZEALAND	COOK IS, SAMOA, TONGA
18:36 – 18:50	04:36 – 04:50	9630 kHz	RADIO NEW ZEALAND	COOK IS, NIUE, SAMOA, TONGA
18:51 – 19:35	04:51 – 05:35	9630 kHz	RADIO NEW ZEALAND	SAMOA, NIUE, TONGA
19:36 – 20:50	05:36 – 06:50	15720 kHz	RADIO NEW ZEALAND	SAMOA, NIUE, TONGA
20:51 – 21:50	06:51 – 07:50	17675 kHz	RADIO NEW ZEALAND	SOLOMON IS, SAMOA, NIUE, TONGA
21:51 – 04:58	07:51 – 14:58	11675 kHz	RADIO NEW ZEALAND	PACIFIC
01:00 – 03:00	11:00 – 13:00	19000 kHz	RADIO AUSTRALIA	PACIFIC
07:00 – 09:00	17:00 – 19:90	7410 kHz	RADIO AUSTRALIA	SW PACIFIC
09:00 – 11:00	19:00 – 21:00	9475 kHz	RADIO AUSTRALIA	SW PACIFIC
11:00 – 13:00	21:00 – 23:00	6080 kHz	RADIO AUSTRALIA	WEST PACIFIC, PNG
13:00 – 15:00	23:00 – 01:00	9890 kHz	RADIO AUSTRALIA	PACIFIC
15:00 – 17:00	01:00 – 03:00	5940 kHz	RADIO AUSTRALIA	SE ASIA
17:00 – 19:00	03:00 – 05:00	9475 kHz	RADIO AUSTRALIA	SE ASIA
14:00 – 18:00	24:00 – 04:00	5845 kHz	BBC WORLD SERVICE	SE ASIA

Fig.4: current DRM transmission times & frequencies in the South Pacific area. With the exception of a BBC World Service transmission, they all come from Radio Australia and Radio New Zealand.

DRM's three data channels

Each DRM broadcasting signal consists of three basic data channels: (1) the Main Service Channel or 'MSC', which generally carries the encoded digital audio data; (2) the Fast Access Channel or 'FAC', which carries a set of data parameters allowing the receiving decoder to quickly confirm things like the modulation system being used in the DRM signals; and (3) the Service Description Channel or 'SDC', which carries 'advance' information like audio and data coding parameters, program service labels, the current time and date and so on.

Fig.3 shows how the three data channels are grouped into the data stream transmitted in DRM30 and DRM+ digital broadcasting. DRM30 modes group the data into 1200ms-long 'super frames' consisting of three frames 400ms long, while DRM+ groups the data into 400ms-long super frames each consisting of four frames 100ms long.

In both cases, the SDC data is transmitted across all subcarriers for a period of two symbols at the start of each super frame. For the rest of each super frame, the FAC data is transmitted using a specific sub-group of subcarriers during each transmission frame, while the coded audio data in

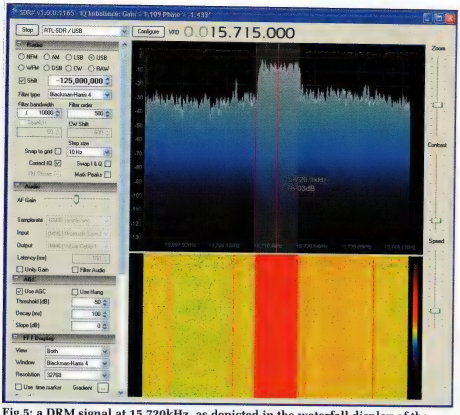


Fig.5: a DRM signal at 15,720kHz, as depicted in the waterfall display of the software program SDR# (running on the SiDRADIO described in the October & November 2013 issues). The DRM signal appears as a rectangular block.

the MSC channel is transmitted using all the remaining subcarriers, in parallel with the FAC data for the rest of the super frame.

DRM status world wide

While we haven't heard much about DRM in Australia, it's now well established in the UK, many European countries, Canada, India and Russia. It is also in Australia and New Zealand, although you'd be excused for not being aware of this. Radio Australia broadcasts DRM30 on shortwave for three hours per day, while Radio New Zealand International broadcasts DRM30 for 20 hours per day (mainly to the Pacific Islands).

To get a better idea of the current state of DRM broadcasting world wide, refer to the map in Fig.1. The countries which currently broadcast regular DRM services are shown in blue, while those which are either conducting trials or have decided to become involved in DRM broadcasting are shown in yellow. As you can see, DRM is already well established.

In fact the Digital Radio Mondiale Consortium claims that there are now over 120 regular DRM services in over 24 different countries and that 'half the world's population' is now in a position to receive DRM (if they had receivers, that is).

Actually, receivers capable of receiving DRM are in short supply and most DRM reception to date seems to have been achieved using PC-based SDRs. However, European manufacturers like Morphy Richards have been producing DRM30 receivers and the Chinese firm Chengdu NewStar Electronics is cranking up production of its DR111 DRM30 receiver. No doubt many other firms in China will follow suit.

DRM30 signals in our vicinity

As mentioned earlier, currently there are only a few DRM broadcast signals in our vicinity (ie, the South Pacific). In fact there are no DRM+ signals at all and only a few DRM30 signals – mainly those being broadcast by Radio Australia from Shepparton in Victoria and Radio New Zealand International (RNZI) in Rangitaiki, in the North Island.

It's true that the BBC directs a DRM30 broadcast into the South-East Asian area for a couple of hours each day (12pm – 2:00am EAST), from their transmitter in Thailand. However you may not be able to find this signal (5845kHz) unless you have a really good HF antenna – a very high long-wire antenna, for example.

You'll find a list of current DRM30 broadcasts by Radio Australia and RNZI in Fig.4, which gives times in UTC and EAST (Eastern Australia Standard Time), together with the frequencies in use.

Sorting Out The Jargon

Don't get DRM (*Digital Radio Mondiale*) confused with DMR. DMR stands for *Digital Mobile Radio*, which is a protocol for narrowband mobile communications.

Also note that the term DRM is also universally used as the acronym for *Digital Rights Management*, a class of technologies used to fight copyright infringement of digital content.

How to identify DRM signals

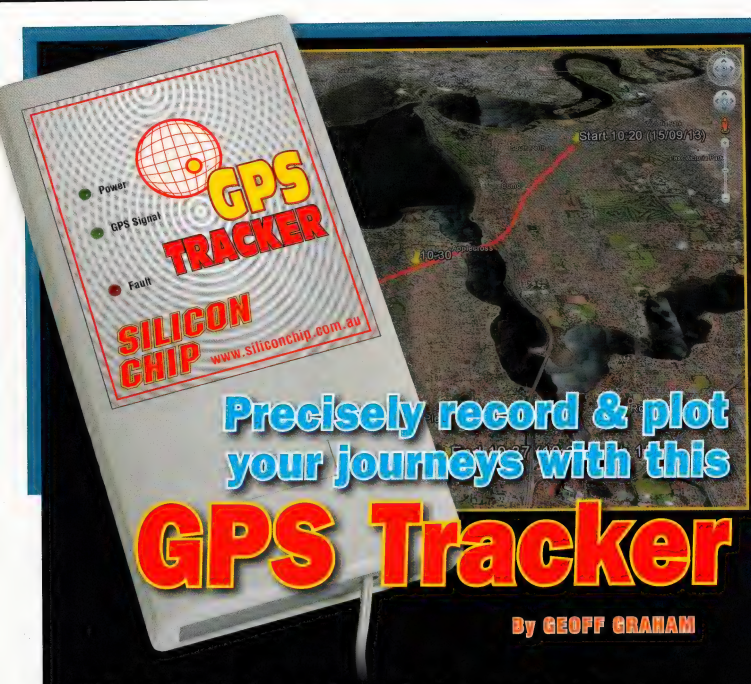
So how can you identify a DRM signal when you're searching for one? If you're using a conventional analog shortwave receiver, it will sound a bit like a 'white noise' signal – just a lot of hissing, whether you're searching in AM or SSB/USB mode.

On the other hand if you're using an SDR with a spectrum display (such as SDR# running on units like the SiDRADIO), a DRM signal will look like a rectangular 'block', as shown in the top area of Fig.5. The DRM signal shown here is not very strong and as a result, its top surface 'dances around' with variations in the individual subcarriers. If the signal were stronger, the top surface of the block would be smoother.

Note that the 'width' of the block will depend on the DRM signal's bandwidth. Most DRM30 signals seem to be 10kHz wide, ie, they occupy 10kHz of the spectrum.

Waterfall plot

The other thing to note is the waterfall plot in the lower area of Fig.5. As you can see, a DRM signal tends to display as a wide vertical 'band', quite different from the much narrower and varying width 'sound track' display produced by an analog AM signal. The band will be fairly solid if the DRM signal is reasonably strong but will tend to have diagonal bands if the signal is weaker. SC



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GPS Tracker

By GEOFF GRAHAM

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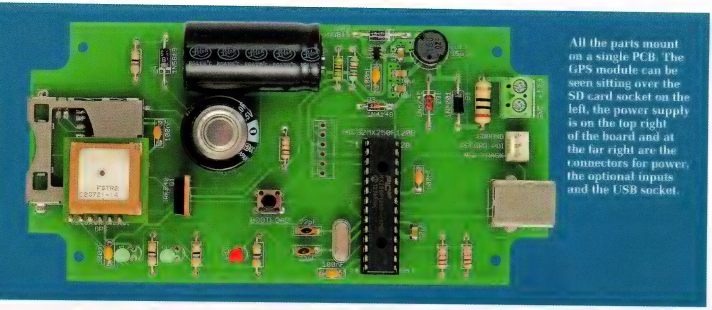


All the parts mount on a single PCB. The GPS module can be seen sitting over the SD card socket on the left, the power supply is on the top right of the board and at the far right are the connectors for power, the optional inputs and the USB socket.

Main Features

- Records the route, time & date on an SD card each time the vehicle is used.
- Stored SD card data can be displayed in Google Earth or other mapping software.
- Records points of interest (POI) at the press off a button. In Google Earth, each POI marker is displayed as a yellow pin with an associated time & distance from the start.
- Record formats: Google Earth KML, GPS Exchange, raw NMEA data & two Microsoft Excel compatible formats.
- Can record POI locations in a spreadsheet called LOG.XLS and can record a travel diary with private & business entries in a spreadsheet called DIARY.XLS.
- When diary recording is turned on, pressing the POI button during a trip means that the distance travelled (in km) is recorded in the "Business" column of DIARY.XLS.
- Powered from the vehicle's 12V battery and can be permanently wired into circuit.

THIS PROJECT was originally created for a couple who were going to do the "grey nomad" trek anticlockwise around Australia in a 4WD and caravan around Australia. Why anticlockwise? Because it's shorter, as you are driving on the left side of the road and on the inside of a circle!

During their journey, they wanted a foolproof method of recording their route without the complications of keeping a log or constantly running a laptop computer with a GPS dongle. This GPS Tracker is the result.

Basically, it's a small box that can be wired to the vehicle's ignition and then forgotten. Each time the vehicle is used, the GPS Tracker automatically records the time, date and the route taken on its SD card. This SD card can be removed later and inserted into a computer so that the stored history can be displayed in Google Earth or some other mapping software.

If you are not a grey nomad, this device can be used for many other tasks – from farmers wanting to know which paddock they ploughed (and when) to boaties or fishermen who would like to know where they have been in the past. It could even be installed in the family car – imagine being able to see precisely the route taken on a particular day some time in the past!

But there's more! The GPS Tracker can also record points of interest (POI) and automatically build a spreadsheet that records a diary of your vehicle's business and private use in a format that (hopefully) not even the tax department could argue with.

A lifetime of detailed travel data can be recorded on a single standard SD card, so the entire history of a vehicle could be recorded for posterity. This data could be useful at some time in the future, especially for a business vehicle.

File formats

The GPS Tracker can record data in five different formats: Google Earth KML, GPS Exchange, raw NMEA data and two Microsoft Excel-compatible formats.

The Google Earth formatted file has an extension of .KML. If you have Google Earth installed on your computer (PC, Mac, or Linux) you only need to double click on the file and it will automatically open in Google Earth and display the track, with markers showing the start, end and points of interest (POI).

Google Earth is free and has many features that assist in displaying your track. These include the ability to zoom in and see detail, combine many separate trips into one overall view and turn visual features on and off.

The second file format is the GPS Exchange Format (ie, file extension .GPX). This is an open XML data format for the interchange of GPS data (waypoints, routes, and tracks) between applications. Many open applications available on the internet use this format.

Google Earth also supports this format but its main use is with software that can automatically work out where you have taken photographs and insert the latitude and longitude into the EXIF data area of the photographs. The software does this by comparing the date and time that your photograph was taken with the date and time in the *GPX* format file.

The third file format supported is the raw NMEA (National Maritime Electronics Association) 0183 data which is stored in a file with a .TXT

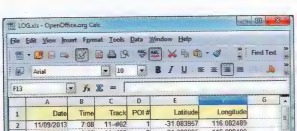


Fig.1: the GPS Tracker can be configured to record POI (point of interest) locations in a spreadsheet called LOG.XLS which makes them easy to reference later on.

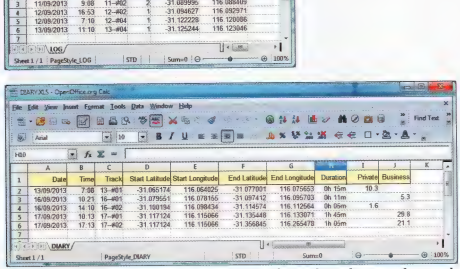


Fig.2: for the tax man, the GPS Tracker can also be configured to record a travel diary in another spreadsheet called DIARY.XLS. In this mode, a trip is deemed to be for business if the POI button is pressed during the journey.

extension. This consists of the RMC (latitude/longitude co-ordinates) and GGA (GPS fix) data records as generated by the GPS module. This format is also used by many applications that can process and display GPS data in interesting ways.

You can configure the GPS Tracker to record the data in one, two or all three of these formats, with a specified interval between records. By default, the GPS Tracker records KML data once every five seconds and GPX data once every minute but this, along with other parameters, can be easily changed (more on that later).

The POI button

As well as recording the track in the three formats listed above, the GPS Tracker can also record data in two different Excel spreadsheets based on the POI input. This input would normally be connected to a switch that would short the input to ground when pressed. The switch could be mounted on the lid of the GPS Tracker itself or more likely, the dashboard of the vehicle or boat.

Pressing the switch causes up to three actions to be carried out. The first is to insert a marker in the KML track. In Google Earth, this marker is displayed as a yellow pin symbol with an associated time and distance from the start. This could be used, for example, to record the location of a likely camping spot or the place that you dropped your lobster pot.

You can also configure the GPS Tracker to record the date, time, latitude and longitude in an Excel spreadsheet (named LOG.XLS) each time the POI button is pressed. This is handy if you want to keep a convenient list of specific locations (see Fig.1).

For example, if you are a farmer driving around your property, you could press the POI button every time you came across a patch of weeds. You could then later print out the spreadsheet and give it to a contractor as a starting list for weed spraying.

Business vs private diary

The second type of spreadsheet file that can be linked to the POI button is a business/private travel diary. As anyone who uses their car for business knows, you have to keep a diary of your business and private use for the tax man. This can be very tedious to say the least but it is necessary so that you can justify the tax deduction.

Diary recording can be turned either on or off and is off by default. When it is enabled, the data is saved in an Excel spreadsheet called DIARY.XLS (see Fig.2). This spreadsheet includes the date/time of each trip, the start and end latitude/longitude, the trip duration and the total kilometres.

If the POI button is pressed during the trip, the kilometres travelled will be recorded in the business column; otherwise they will be recorded in the private column.

So, all you need do is press the POI button sometime during each business trip and your complete travel diary will be automatically created, ready to be attached to your tax return.

Design

Because of its intended use, the GPS Tracker was designed to be as simple and foolproof as possible. As shown in the photos, it's housed in a small ABS case with a power cable (+12V from the vehicle's ignition) feeding in at one end and a slot to insert the SD card at the other. There are also three indicating LEDs on the front panel and that's it.

The firmware is designed to be as forgiving as possible and will automatically recover from events such as loss of the GPS signal and power failure.

Circuit details

Take a look now at Fig.3 which shows the complete circuit. It consists of three main sections: a microcontroller (IC1), a GPS module and a switching power supply.

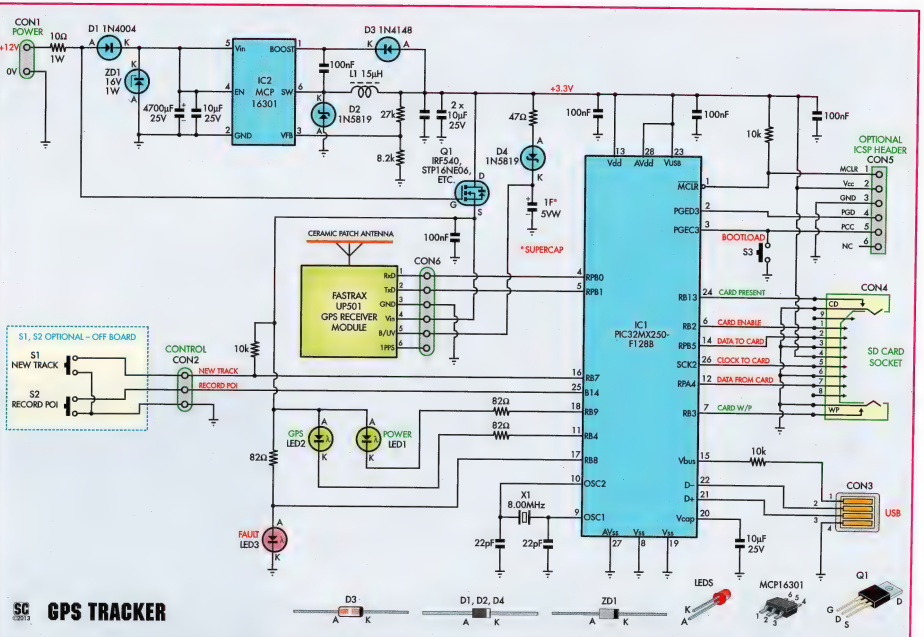
The microcontroller used is a PIC-32MX250F128B, the latest variant from the Microchip PIC32 stable. This was chosen because of its performance – it has a 32-bit processor, the clock runs at 40MHz and it has a large integrated flash memory (128KB).

When you think of it, the microcontroller has quite a heavy workload. Primarily, it must implement a full FAT16 or FAT32 file system on the SD card, with the ability to create subdirectories and navigate through them. It also must be fast enough to close any open files and flush the data to the SD card if the power fails.

But the best features of this high-performance chip are that it is cheap and comes in a standard 28-pin DIP package that can plug into an IC socket.

Power supply

The GPS Tracker is intended to be



GPS TRACKER

Fig.3: the GPS Tracker consists of three main sections – a microcontroller (IC1), a power supply (IC2) and a GPS module. The power supply is designed to provide a regulated 3.3V supply for up to two seconds after the 12V supply has been removed.

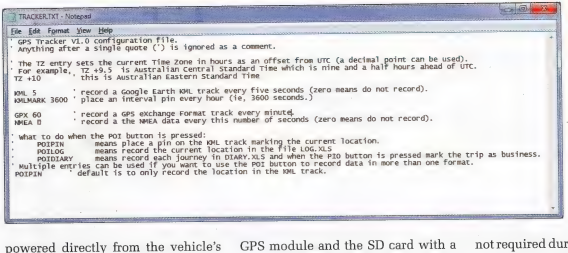


Fig.4: this is the default configuration file created by the GPS Tracker if a blank SD card is used. You can use any ASCII editor (Notepad in this example) to change the settings to your preference.

powered directly from the vehicle's ignition supply. It can either be hard-wired to the fuse block or it can be powered from a cigarette lighter socket (ie, via a flying lead fitted with a cigarette lighter plug).

In practice, the power supply must protect the microcontroller and the GPS module from spikes and reverse voltage. It must also keep supplying power for a short time after the external supply is removed, to allow data to be written to the SD card. As a result, it's more complicated than a simple 3-terminal regulator circuit.

Transient protection is provided by a 10Ω resistor and 16V zener diode ZD1. These serve to clip any transients while diode D1 (1N4004) provides reverse polarity protection and isolates the main filter capacitor (4700µF) from the vehicle supply when power is removed.

IC2, an MCP16301, is an efficient step-down voltage regulator. This supplies the microcontroller, the GPS module and the SD card with a regulated 3.3V rail. When power is removed, the charge on the 4700µF input capacitor will decay and the regulator will track this falling voltage while still delivering a stable 3.3V output.

In operation, IC2 can keep its 3.3V output stable for almost two seconds after power has been removed.

The microcontroller needs only about 0.3s to flush its data and close the files on the SD card, so using a 4700µF capacitor sounds excessive. However, there's sufficient space on the PCB to accommodate it and using such a high value provides a wide safety margin that will accommodate the inevitable reduction in its capacitance due to heat and aging.

When power is removed from the unit, we need to minimise its current drain so that the 3.3V supply can be maintained for as long as possible. This is achieved by Q1 which immediately disconnects the power to the LEDs and the GPS module (which is not required during shut-down) when the power is removed.

As shown, Q1 is an N-channel Mosfet which has its gate connected to the supply rail (ie, before reverse polarity protection diode D1). When the ignition is on, this holds Q1's gate at about +9V with respect to its source and therefore Q1 is turned fully on.

When the ignition is subsequently turned off, Q1's gate voltage immediately falls to zero. As a result, Q1 quickly turns off and in turn removes power to the LEDs and the GPS module.

The main requirement of Q1 in this role is that it should have a low drain-source resistance when turned on. There are many SMD FETs that have this feature but it is easier to use a commonly-available power FET, even though we are only switching about 50mA.

New track input

When the input power is removed, IC1 detects this on its RB7 input (pin 16) and immediately commences its shut-down routine. This involves terminating the current track and writing the cached data to the SD card.

RB7 of IC1 is also connected to CON2 to provide the "NEW TRACK" input but note that a new track is also automatically started if the unit loses power. Shorting this input to ground signals that the current trip has finished. When the short is released, the unit will then start recording a new track.

This facility is provided so that the Tracker can be permanently connected to power if required. The advantage of this is that there will be no delay in it recording the current location, as would otherwise initially occur when power is first applied. Also, because of the efficient power supply design, the GPS Tracker only consumes about

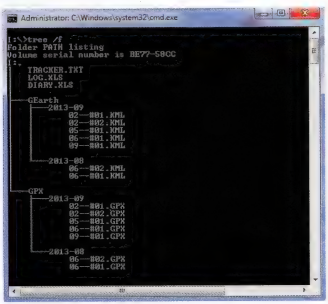


Fig.5: this is the directory structure created to hold the data. It consists of three top level directories (GEarth, GPX and NMEA) with sub directories for each month. A file is created within these subdirectories for each trip.

50mA and that level of permanent drain is acceptable in a vehicle that's driven regularly.

LEDs1 & 2 (green) indicate power and correct GPS operation respectively. These are connected between Q1's source and the microcontroller which pulls its RB9 & RB4 outputs low to turn them on.

LED3 (red) is the fault indicator and its drive arrangement is a little different. As shown, it's connected between the RB8 output and ground. Normally, the microcontroller turns LED3 off by pulling its RB8 output low, which shorts out the LED. This means that the LED is off as long as the microcontroller is working normally. However, if anything goes wrong with the microcontroller, the LED turns on to indicate a fault.

The firmware also monitors other components such as the GPS module and the SD card and if anything is wrong, it will turn on the fault LED. That way, the user is immediately warned that data is not being recorded – important in a device that is supposed to work automatically.

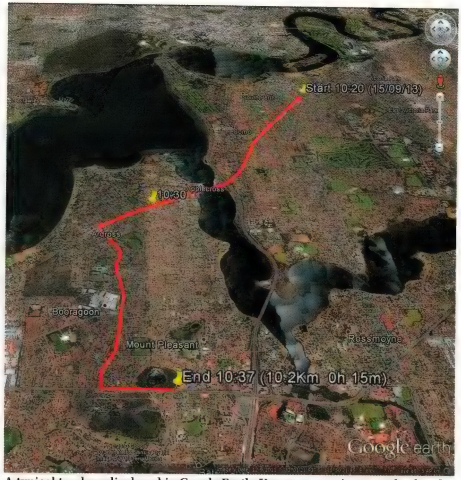
GPS module

The GPS Tracker is primarily designed for use with the UP501 GPS module from the Finnish company Fastrax. This amazingly small module is cheap, available from many sources and plugs neatly into the PCB. However, if you want to use an alternative, the firmware will also work with the Globalsat EM-408 module that's been used in many of our projects in the past.

The advantage of the EM-408 is that it is a little more sensitive and it has an MMCX connector for attaching an external antenna. However, it is more expensive than the UP501 and is difficult to mount securely inside the case.

The UP501 needs a back-up supply to keep the internal memory of the module alive when power is removed. This is important because it can take a long time for the module to get all the data it needs from the GPS satellites. Provided the back-up supply is maintained above 2V, the module will remember this information and can get a fix on the satellites and your location more quickly.

Therefore, a 1-farad super-capacitor has been included to keep the module's memory alive for up to a week. As shown on Fig.1, this is connected between the GPS receiver's V_{DD_B} pin (pin 5) and ground. On the other hand, the EM-408 has an internal super-capacitor, so the external super-capacitor, diode D5 and the associated 47Ω resistor can be omitted if this module is used.



A typical track as displayed in Google Earth. You can zoom in to see the detail of the track or you can zoom out as in this image to see the whole route. The start marker records the start time and date, while the end marker records the end time, the distance travelled and the duration of the trip.

USB port & ICSP

IC1 provides a USB port at pins 15, 22 & 21 (Vbus, D- & D+ respectively). This is used only for debugging, as discussed later.

The PCB layout also has provision for an ICSP (in-circuit serial programming) connector (CON5) which is not normally fitted. However, if you purchase a blank microcontroller, you can fit this connector and use a programmer such as Microchip's PICkit 3 to program the chip in circuit.

Configuring the tracker

When the GPS Tracker starts up, the first thing the firmware does is read its configuration settings from a file called "Tracker.txt" in the root directory of the SD card. If that file is not found the firmware will automatically create it using its default settings.

Fig.4 shows the typical contents of this file and as you can see, the comments make the file reasonably self-explanatory. In fact, the best way to create a custom configuration for the GPS Tracker is to insert a blank SD card and let the firmware create the default configuration file. You can then edit that file to suit your preferences.

The main parameter that you might want to change is the time zone that you are operating in. The GPS Tracker gets an accurate time from the GPS satellites but it needs to know your time zone so that it can convert the GPS time to local time for time stamping its records.

Another parameter that you might like to adjust is how often the GPS data is recorded on the SD card. This can be independently set for each of the three main data formats (KML, GPX

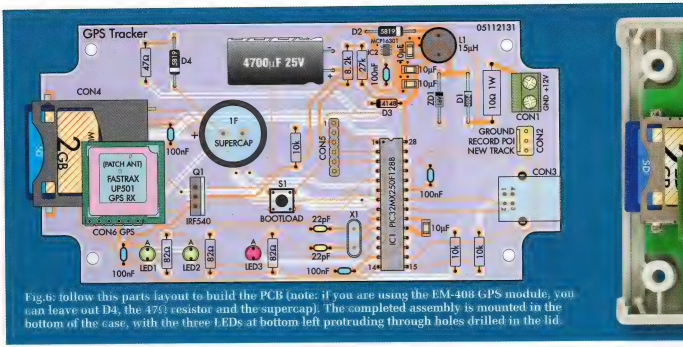


Fig.6: follow this parts layout to build the PCB (note: if you are using the EM-408 GPS module, you can leave out D4, the 47Ω resistor and the supercap). The completed assembly is mounted in the bottom of the case, with the three LEDs at bottom left protruding through holes drilled in the lid.

and NMEA) and can be as often as once a second for accurate recording all the way up to many minutes if you want to keep the data files small.

The KLMARK parameter controls how often (in seconds) a timed marker is placed on the KML track. This can be handy for long trips as it gives you an indication in Google Earth of your progress during the trip. A setting of zero will disable this feature.

The parameters POIPIN, POILOG and POIDIARY are associated with the POI input and don't have an associated value. Just their presence in the configuration file means that that feature will be turned on.

POIPIN means that a marker pin will be placed on the KML track when the POI input is pulled low. POILOG means that the date, time, latitude and longitude of the current location will be recorded in the log file (LOG.XLS) when this happens.

Finally, POIDIARY means each trip will be recorded in a travel diary (DIARY.XLS). If POIDIARY is enabled and the POI input is pulled low at any time during a trip, it will be recorded as a business trip.

Capacitor Codes

Value	µF Value	IEC Code	EIA Code
10µF	10µF	10u	106
100nF	0.1µF	100n	104
22pF	NA	22p	22

Directory structure

Over time, the GPS Tracker can accumulate a lot of data, so a directory structure is used to make it easier to locate a particular trip. Fig.5 illustrates this structure.

Starting with a blank SD card, the firmware will create three directories called GEARTH, GPX and NMEA – one for each of the three data formats to be recorded. Within each directory, it will create a subdirectory for each month. The format of the subdirectory name is year-month. For example, the directory "2013-12" will contain the records for December 2013.

Finally, within these subdirectories, each trip will be recorded as a separate file. The file name starts with the day of the month followed by a sequence number for that day. So a file with the name "12--#03.KML" is the third trip recorded on the 12th day of the month.

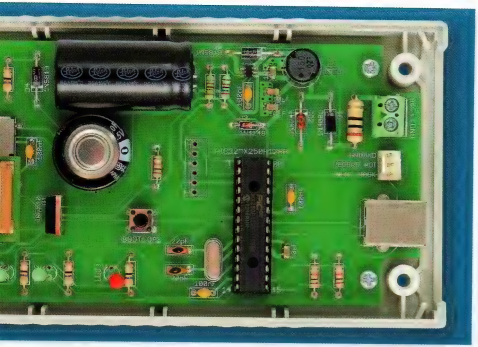
If required, the Excel spreadsheet files (LOG.XLS and DIARY.XLS) will also be created in the root directory of the SD card. They just accumulate data so if you want to reset them, it's just a matter of deleting them and the firmware then recreates these two .xls files with zero size the next time it starts up.

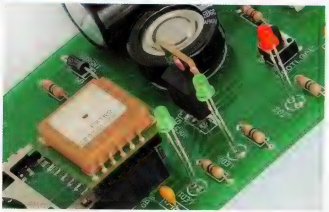
The firmware keeps these and other files open while it's recording a journey. This means that you must not remove the card while it is being used, as that will result in a corrupted file system. Instead, you must always make sure that the power has been removed for a second or two (or the NEWTRACK input pulled low) before removing the card.

The firmware will work with most SD cards up to 32GB in size and formatted with FAT16 or FAT32. Larger

Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	27kΩ	red violet orange brown	red violet black red brown
❑	3	10kΩ	brown black orange brown	brown black black red brown
❑	1	8.2kΩ	grey red red brown	grey red black brown brown
❑	3	82Ω	grey red black brown	grey red black gold brown
❑	1	47Ω	yellow violet black brown	yellow violet black gold brown
❑	1	10Ω	brown black black brown	brown black black gold brown





This close-up view shows how the UP501 GPS module and the three LEDs are mounted. The LEDs must be 20mm proud of the PCB so that they protrude through the case lid.

cards may also work but we haven't tested them. However, we expect that larger cards will work if reformatted using the FAT32 file system.

Typically, a track that is recorded once a second will require about 2MB of storage per 1000km travelled, although this can vary considerably depending on your driving patterns.

These days, an 8GB SD card can be as cheap as $10. So, using 8GB as the benchmark, you will be able to record all three data formats at the rate of once a second for over 1,000,000km. Obviously, storage capacity is not an issue!

Construction

The GPS Tracker is built on a double-sided PCB coded 05112131 and measuring 137mm x 68.5mm. Fig.6 shows the parts layout.

Most of the parts are through-hole devices, so the assembly is fairly straightforward. However, voltage regulator IC2 and the four 10µF capacitors are surface mount devices (SMDs) and these parts must be fitted first.

To mount each SMD, first apply plenty of liquid flux to its PCB pads. That done, place the component in position and hold it down with tweezers or a matchstick while you put some solder on the tip of your iron and tack-solder one pin (or end). Adjust its position by remelting the solder and nudging it slightly if necessary, then solder the remaining pin(s).

Finally, return to the original pin and add more solder, to ensure it is soldered correctly. Don't worry if you get a solder bridge between two pins when soldering IC2. The bridge can be easily removed after the device has been fitted using solder wick.

Note that, for performance reasons, the components around the voltage regulator are closely packed. Check Fig.6 carefully to ensure that each device is correctly positioned. **In particular, when fitting IC2, take care to ensure that you identify the faint dot marking pin 1 of the package.**

Once the five SMDs are in place, continue by fitting the remaining parts, starting with the low-profile components (resistors, etc) and then moving on to the taller components. Crystal (X1) should be installed sitting about 2mm above the PCB, so that its metal case doesn't short against the solder pads underneath. This can be easily achieved by pushing the crystal down onto a thick cardboard spacer which is then removed after the leads have been soldered.

Note though that the PCBs supplied by SILICON CHIP should have a solder mask layer over these pads on the top of the board, so in this case the crystal can be pushed all the way down.

A 28-pin DIL socket is used for microcontroller IC1. Be sure to install it with its notched end positioned as shown on Fig.6.

Fitting the SD card socket

Another part that needs special treatment is the SD card socket which is surface mounted. It has two small plastic posts on the underside that mate with matching holes in the PCB to ensure it is correctly positioned.

In particular, make sure that you find and solder all the SD card socket's solder tabs – there are 16 in total. Two of these are very close together on the front lefthand corner of the socket (viewed from the front) and both should be soldered to the same solder pad.

Other parts

As shown in Fig.6, the 4700µF capacitor is mounted side-on against the PCB. That means that you have to bend its leads down by 90° before fitting it, so that they pass down through the PCB pads. Take care to ensure it is orientated correctly and place a dob of hot-melt glue or neutral-cure silicone under the capacitor before pushing it down into place. This will ensure that it is held against the PCB and prevent it later fracturing its PCB pads due to vibration (the unit is intended for use in a vehicle after all).

LEDs1-3 are mounted 20mm proud of the PCB, so that they later protrude through their respective front-panel holes. To set the correct height, cut a 20mm-wide strip of thin cardboard

This is the level of detail that you can see in Google Earth. The red line is the track of the vehicle and in this case you can even see what traffic lane it was travelling in.

and slide it between the legs of each LED while you solder it into position. Make sure the LEDs are all correctly orientated, ie, with their cathode (K) leads towards the edge of the PCB.

GPS module

The UP501 GPS module plugs into a 6-pin header socket which positions the module over the SD card socket (see Fig.6 and photos). If you are using this GPS module, simply solder a 6-pin header onto the module. It's subsequently plugged into the socket on the PCB after the initial testing.

Alternatively, if you are using the EM-408 GPS module, you need to cut off one of the connectors from the supplied cable and solder the leads to a 6-pin header as shown in Fig.7. This header is then later plugged into the header socket on the PCB.

As discussed earlier, if you are using the EM-408, you can leave out the super capacitor, diode D4 and the associated 47Ω resistor. However, these parts should be fitted for the UP501.

A problem with the EM-408 is that there's no easy method of mounting it securely. One way around this is to sit the module (with its integrated aerial facing up) on top of a block of soft foam which in turn sits on top of the PCB. Then, when the lid is screwed down, you will have a "squashed sandwich" arrangement which will push the module against the lid of the box, thereby holding it in place.

Alternatively, you may be able to secure it to the top of the SD card socket using double-sided adhesive foam. Make sure that the adhesive cannot come into contact with the SD card when it is inserted though.

The assembled PCB fits neatly into the specified plastic instrument case and is secured at all four corners using short M3 or self-tapping screws. Fig.8 shows the drilling details for the lid (to accept the three LEDs), plus the location of the cut-out required in one of the end panels to accommodate the SD card.

The USB connector is used only for debugging, so there's no need to make a cut-out for it in the opposite end panel. However, you will need to drill a hole in this panel for the power lead.

A vehicle is a high vibration environment so both the microcontroller and the GPS module must be secured to prevent them from vibrating loose. The best way to do this is to cut two pieces of high-density foam (the type used to package heavy appliances) and glue them to the lid, so that they press down onto these devices when the lid is later fastened into place.

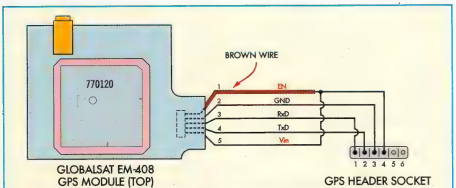


Fig.7: if you use the EM-408 GPS module, cut off one connector from the supplied cable and then solder the cable to a 6-pin header as shown here. This header is then plugged into the GPS header socket on the PCB.

Testing

Before plugging in microcontroller IC1 and the GPS module, you should first test the operation of the power supply. To do this, connect the PCB to a 12V supply and check that there is 3.3V (3.1-3.45V range) between pins 13 (+) and 19 (-) of the IC socket. At the same time, the red fault LED should illuminate.

Next, remove the power and check that the 3.3V rail remains for a few seconds (this indicates that the 4700µF capacitor is doing its job). Wait for this rail to drop to almost 0V, then complete the PCB assembly by inserting the microcontroller and GPS module into their sockets.

Using the tracker

Using the GPS Tracker is as simple as applying power, inserting the SD

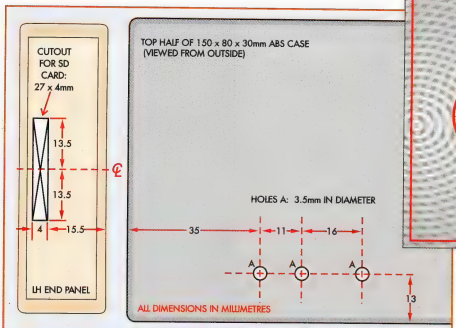


Fig.8: use these two templates to make the SD card slot cut-out in one of the end panels of the case and to drill the holes for the LEDs in the lid.

Fig.9 (above): this front-panel artwork can be copied, laminated and attached to the case lid using silicone. It's also available in PDF format on the SILICON CHIP website.

card and checking the three indicator LEDs. The first of these is the power LED and it only comes on when the microcontroller has completed its self test routine, indicating that both the power supply and the microcontroller itself are OK.

The second is the GPS signal LED. This will be off if the GPS module could not be detected (ie, disconnected), flashing if the module is in communication but has not got a fix on sufficient satellites, and steadily illuminated if it has a fix and a valid latitude and longitude.

Note that you need to be a little patient when you first power it up, as it can take up to 15 minutes for the GPS module to get its first fix. So place the device somewhere where it has a clear view of the sky and give it some time.

The third LED (red) is used to signal a fault. As explained earlier, this LED will come on if a fault is detected, including a faulty or disconnected GPS module, a faulty or unprogrammed microcontroller or a problem with the SD card. Note that a loss of the GPS satellite signal is not counted as a fault because you may be travelling through a tunnel and the GPS Tracker will resume recording when you exit and the signal is restored.

If the red fault LED is illuminated, you can deduce the general location of the fault from the other LEDs. For example, if the fault LED is on and both the green LEDs are on, this indicates that the microcontroller and GPS are OK and therefore something must be wrong with the SD card.

Typical problems with the SD card include not being inserted correctly, having the write protect switch in the on position and a corrupted and/or incorrect file system on the card. Any of these will light the fault LED.

When the GPS Tracker is running normally, the fault LED will be off and the green power and GPS signal LEDs will be on. Whenever the tracker saves an item of information to the SD card, the power LED will blink momentarily to give an indication that it is active and recording your position.

One point to note is that when you are testing the unit on the bench, you will find that it does not record any data. That's because it will only record trips that cover more than 100 metres. This feature was included to avoid recording trivial vehicle movements, like moving a car from the driveway to the garage.

Installation

Installing the GPS Tracker can be as easy as securing it to the top of the dashboard using Velcro (or similar hook & loop material) and using a cable with a cigarette lighter plug for power. For a more permanent instal-

The GPS Tracker sitting on the dashboard of a vehicle. It can be held in place using hook & loop material (eg, Velcro).

GPS Tracker Parts List

1 PCB, code 05112131, 137mm x 68.5mm (available from the SILICON CHIP Online Shop)
1 ABS box 80 x 150 x 30mm (Altronics H0218, Jaycar HB-6034)
1 front panel label, 71 x 85mm
1 UP501 or EM-408 GPS module
1 8MHz crystal (X1)
1 15µH 2.1A choke (L1) (Panasonic ELC09D150F or similar)
1 28-pin narrow DIL IC socket
1 tactile pushbutton switch (S1)
1 2-way screw terminal block, 5.08mm pitch (CON1)
1 3-way polarised male header, PCB-mount, 0.1-inch pitch (CON2)
1 Type-B USB socket, PCB mount (CON3) (Jaycar PS-0920, Altronics P1307)
1 SD memory card connector (CON4) (Altronics P5720)
1 6-pin male header, PCB mount, 0.1-inch pitch (CON5, optional)
1 6-pin male header, PCB mount, 0.1-inch pitch (for GPS module)
1 6-pin header socket, PCB-mount, 0.1-inch pitch (CON6)
4 M3 x 5mm machine screws (or No.4 x 6mm self tappers)
2 momentary pushbutton switches (optional – see text)

Semiconductors

1 PIC32MX250F128B-I/SP microcontroller programmed with 0511213A.hex (IC1) (available from the SILICON CHIP Online Shop)
1 Microchip MCP16301T-I/CHY switching regulator (IC2)
2 3mm green LEDs (LED1,LED2)
1 3mm red LED (LED3)
1 IRF540, STP16NE06 or PT3055V Mosfet (Q1) (TO-220 package)
1 1N4745 16V 1W zener diode (ZD1)
1 1N4004 diode (D1)
2 1N5819 Schottky diodes (D2,D4)
1 1N4148 silicon diode (D3)

Capacitors

1 1F 5V super capacitor, PCB mount, 5.08mm lead pitch
1 4700µF 25V electrolytic
4 10µF 25V ceramic, SMD 1206
5 100nF monolithic ceramic
2 22pF ceramic

Resistors (0.25W 1%)

1 27kΩ	3 82Ω
3 10kΩ	1 47Ω
1 8.2kΩ	1 10Ω 1W

Note: a kit of parts for this project will be available from Jaycar, Cat. KC5525.

Finding The Parts

As usual, a high-quality PCB for the project can be purchased from the SILICON CHIP Online Shop at www.siliconchip.com.au A pre-programmed microcontroller (PIC32MX250F128B-I/SP) can also be purchased from the Online Shop or you can purchase a blank chip direct from Microchip (www.microchipdirect.com), element14 (Cat. 2097773/2096412) or RS Components (part 768-0836).

Note that if you purchase a blank microcontroller, you will need a programmer (such as a PICkit 3) to install the firmware. The hex file is available on the SILICON CHIP website.

The voltage regulator (Microchip MCP16301T-I/CHY) can be purchased on-line from Microchip Direct or RS Components (part number 770-9476P). element14 also have the 15µH choke and 10µF SMD capacitors (Cat Nos 8094799 and 1845759 respectively), as do RS Components (part numbers 540-8538 and 758-8093 respectively).

Finally, the UP501 GPS module can be purchased from either RS Components (part 716-5283) or Element14 (part 2113837). If you prefer the EM-408 module, it can be purchased from Altronics (Cat. K-1131) and from many online parts shops.

lation, it could be placed on the rear parcel shelf, in the glove box or under the dashboard and permanently wired to the vehicle's ignition supply (ie, the 12V supply that's available when the engine is running).

In some locations, such as under the dashboard, it's possible that there will be insufficient signal for the module to acquire or maintain a reliable satellite fix. To assess this, you can carry out a simple test. First, place the GPS Tracker on top of your vehicle with a clear view of the sky (no trees, tall buildings, etc) and leave it for half an hour or so to get a solid fix and charge the super-capacitor.

That done, remove the power, swiftly place it in its intended location and reconnect the power. If the signal level is excellent, the GPS module should regain a fix (indicated by a solid green GPS LED) within 10 seconds. If the signal is marginal, it might take up to a minute or more with the LED blinking before a fix is found. Anything between these two is an indication of the signal strength.

If the signal level is inadequate, you could remotely mount the GPS module in a location with a better signal and connect it to the PCB using a 6-core cable up to 2m long. Note that the aerial is on the top of the GPS module and this needs to be aimed straight up at the sky for best reception (ie, the module should be horizontal).

If you are using the EM-408, you can go further and purchase an external antenna with an MMCX connector and plug it into the module. These are available cheaply on eBay and other on-line sources and they will provide a strong signal, even in adverse situations. They are also waterproof and have a magnetic base, so the antenna can be mounted externally on the vehicle with a good view of the sky.

If you are using the two optional inputs (POI and NEW TRACK), then you will have to add momentary pushbutton switches to short them to ground. The maximum voltage on these inputs is 3.3V so don't connect them to the vehicle's 12V system **(note: if these switches are mounted remotely from the case, it may be necessary to connect them using shielded cable to prevent glitches).**

Alternatively, the NEW TRACK input can be connected to the vehicle's ignition circuit in order to automatically create a new track each time the

ignition is switched off (only necessary if the unit's power supply is not switched with the ignition). This involves connecting a diode between CON2 and the ignition line, with the diode's anode going to CON2. This pulls the NEW TRACK input low each time the ignition is switched off but prevents 12V from being applied to this input (which would damage it).

Fault finding

If you have a problem with your GPS Tracker, the first thing to do is check the indicator LEDs. If no LEDs are illuminated it indicates a power supply problem and you should check the input supply for 12V and the regulator output for 3.3V.

If the red fault LED is on but no other LEDs are illuminated, this indicates that the microcontroller has a problem. Most of the time, this will be because it has been inserted the wrong way around. If so, reverse it and pray that it survived. Another possibility is the 10µF capacitor connected to pin 20 of the microcontroller. It must be a low-ESR ceramic device; anything else could prevent the microcontroller from starting up.

If the GPS signal LED does not come on at all, it indicates that the GPS module is not communicating. This could be because it is not plugged in correctly, the super-capacitor is missing, it is configured for the wrong baud rate or it is faulty (unlikely).

If you suspect the module, use the USB connector to connect the GPS Tracker to a desktop computer. For Windows, you need to install the SILICON CHIP USB Serial Port Driver (available on the SILICON CHIP website) but this isn't necessary for Mac and Linux computers which have built-in drivers. The installation instructions are included with the driver.

Next, use a terminal emulator to open the virtual serial port over USB, as created by the GPS Tracker on your computer. When you do, you should see the NMEA data stream as it is produced by the GPS module. There are many free applications that you can download that can use this data to diagnose your module. If you are a 4WD off-road enthusiast you could connect the tracker to a laptop via USB and use an application like *ExploreOz* which will use the NMEA data stream to pinpoint your position on a map.

You can also use this facility to send commands to the module but you should avoid changing its baud rate as that parameter will be stored in its internal memory and will be recalled on power up. That could make it impossible to communicate with your module, even after the power has been cycled.

If the NMEA data is missing and everything else is OK (including the supply rail to the module), then the module is probably faulty.

This view shows a week long camping trip as recorded by the GPS Tracker. If you are on a long tour, you can use Google Earth to aggregate many individual tracks over many days to provide a "high-level" view of your progress across the surface of the earth.

Firmware updates

For firmware updates, you should check the author's website (http://geoffg.net/tracker.html). To load a new firmware image, hold down the BOOTLOAD button while applying power to the GPS Tracker. The power LED will then flash slowly, indicating that the unit is in bootload mode.

Next, copy the new firmware file (it must be called TRACKER.HEX) to the root directory of an SD card and insert it into the SD card socket. The power LED will then flash rapidly as the image is read from the card and programmed into the microcontroller's flash memory. The whole process only takes about 10 seconds and when it is finished, the GPS Tracker will automatically start running the new firmware.

If an error occurs, the power LED will resume its slow flash and the red fault LED will come on. Possible causes include: (1) a missing or incorrectly named hex file, (2) a hex file that is corrupted in some way and (3) a marginal or noisy power supply. After you have identified and corrected the issue, you can run through the bootload process again.

So, there you have it – a versatile gadget that can record a lifetime's worth of travelling. Where are you going to go with it? SC

By NICHOLAS VINEN

Audio delay for PA systems

If you have ever been in a hall or concert venue which has multiple speakers, you will know that intelligibility can be a real problem. This is caused by the different propagation times of the sounds from speakers near and far away from you. How do you fix it? By adding an audio delay. This unit does that by delaying the audio signal from the microphone by up to 640 milliseconds. But that's just the beginning of its capabilities. It is actually a fully-fledged stereo DSP board with a 32-bit processor running at 80MHz and with appropriate software, is capable of providing other effects such as echo, reverb and compression.

PA SYSTEMS IN HALLS and larger venues can often present a problem with intelligibility, especially if you are sitting up the back. Picture the situation in a large church, for example. There will typically be a pair of large column speakers up the front of the congregation but they cannot be turned up enough so that people up the back can hear the proceedings. So another pair of column speakers might be installed half way along or further back in the church.

That should mean that people up the back can now hear what's going on but now the sound becomes jumbled because while the sound from the speakers close to you may be loud enough, it is actually being muddied by the delayed sound from the speakers up the front.

The solution is to delay the sound coming from the rear speakers and that is what this project does. In practice,

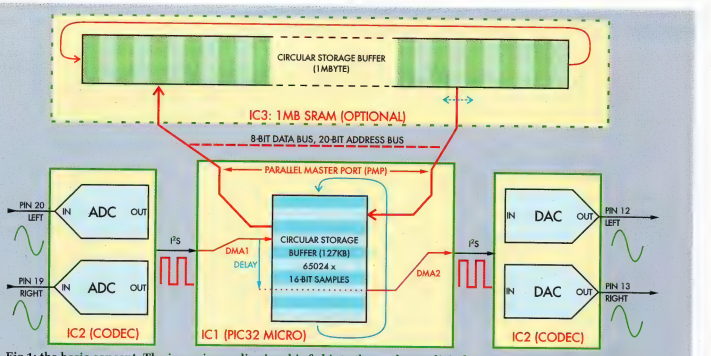


Fig.1: the basic concept. The incoming audio signal is fed into the analog-to-digital converter (ADC) of CODEC IC2 and the resulting digital data then fed into a circular recording buffer which is 127kB of the static RAM on a PIC32 microcontroller (IC1). The delayed signal is then picked off from within this buffer and converted back to audio by IC2's digital-to-analog converter (DAC) section. SRAM chip IC3 is added if you want a delay of more than 640ms.

if the distance between the front and rear speakers is more than about 10 or 15 metres, an audio delay can be very worthwhile.

Of course, this means that you need two separate PA systems: one for the rear speakers with the audio delay and one for the speakers at the front of the hall, church or whatever.

But what if you have a much larger hall? In that case, you might need to break the PA installation into three, with two sets of audio delays. Guess what? This project can also cater for that. In the simple mode, with just one delay required, it can operate in stereo. If two audio delays are required, it can operate with two separate channels, each with their own delay.

Now some PA systems can have pretty good fidelity, so we wanted to produce the audio delay(s) while adding very little distortion and noise to the signal. We also wanted the delay unit to be cheap and easy to build.

The solution was to combine an all-in-one audio CODEC chip (digital COder/DECoder) with a PIC32 microcontroller that has a digital audio interface. These two chips, plus a few support components, give a 24-bit, 96kHz stereo analog-to-digital converter (ADC), a similar digital-to-analog converter (DAC) and enough processing power and memory for quite a long delay.

In fact, with its 128KB of internal RAM, the PIC32 we have chosen can provide a delay of up to 640 milliseconds. It also has a Parallel Master Port (PMP) which can interface directly with a standard static RAM (SRAM) chip. This allows us to have provision for up to 1MB of additional RAM to be used in case even longer delays are needed – up to six seconds, in fact. That could be useful in a very large venue such as a surf carnival, with speakers spread along several hundred metres of beach.

We're using a sampling rate of 48kHz and a 16-bit voltage resolution, as this gives near-optimal performance with the CODEC chip we are using while keeping memory storage requirements modest. The ADC performance is the limiting factor.

By the way, the author has published two previous audio delay units but this one has features lacking in those. For example, the SportSync from May 2011 can be set for a long delay but it only has one channel (ie, mono) and its sound quality is not especially high, being intended for use with AM radio sports commentary.

The second previous unit, the Digital Audio Delay from December 2011, only has digital audio inputs and outputs while this unit only has analog inputs and outputs, so they are suited for different purposes.

Note that this is the first microcontroller-based audio delay we have published that does not require an external SRAM chip thanks to the large 128KB internal RAM in the PIC32.

Delay concept

The method of providing an audio delay is very similar to that employed in the abovementioned projects and Fig.1 shows the concept. The signal from the audio mixer is fed at line level into the analog-to-digital converter (ADC) of the CODEC. The digital data is then fed into a circular recording buffer which is 127 kilobytes of static RAM on the PIC32 microcontroller. We can then pick off the output signal from anywhere within this buffer.

Depending on the sampling rate (in this case, 48kHz), the difference between when the data is written and read out determines the time delay. Of course, the delayed data signal must then be converted back to audio by the digital-to-analog converter (DAC) section of the CODEC.

So in essence, only two chips are required: microcontroller IC1 (the just-released PIC32MX470F512H) and the

Features & Specifications

- Adjustable stereo delay of 0-640ms (6s if optional SRAM chip fitted)
- THD+N <0.03% (typically <0.02%), 20Hz-20kHz (20Hz-22kHz bandwidth; see Fig.6)
- Signal-to-noise ratio typically >76dB
- Optimal input signal range 0.5-2V RMS
- Output signal 1V RMS
- Input impedance 6kΩ (DC), 4kΩ (20kHz)
- 7.5-12V DC plugpack supply, current drain 60-80mA
- Delay adjustment via internal trimpot or external control knob
- Uses the latest PIC32 microcontroller
- Future expansion can add extra modes such as echo, reverb and compression

stereo audio CODEC, IC2 (WM8731). An optional static RAM (SRAM) chip (IC3)is only fitted if you want a delay of more than 640 milliseconds (see Fig.3).

Circuit description

Fig.2 shows the circuit with IC1 and IC2. If you look at the PCB for this project, you will notice that there is provision for many more components than are used in this circuit. One of those is IC3, which is shown in Fig.3. All the other "missing" components will be featured in future projects which will employ the same core circuit.

So, referring to the top left-hand corner of the circuit, the unbalanced stereo audio signal is applied to 6.35mm jack socket CON1. If a mono plug is used, the signal will be applied to the right channel input while the left channel input will be shorted to ground.

The left and right channel signals first pass through RC filters comprising 1kΩ resistors and 1nF capacitors, to remove ultrasonic and RF components which would interfere with the ADC's operation. The signals then go into adjustable attenuators which consist of two 5kΩ trimpots, VR5 & VR6. While these can be individually adjusted, normally they would be set to give the same signal level for both channels.

These attenuators are required because IC2 runs off 3.3V and thus it can only handle a signal of up to about 1V RMS (2.828V peak-to-peak) before clipping. For input signals below 1V RMS, VR5 & VR6 are set at maximum. The attenuated signals are AC-coupled to IC2's inputs by 1µF non-polarised capacitors. In order for the signal handling to be maximised and for symmetrical clipping in the event of overload, the input signals are biased to half the supply voltage of 3.3V, ie 1.65V.

This half-supply DC bias comes from IC2 and is fed to the line inputs at pins 19 & 20. This voltage also appears at pin 16 (VMID) where it is filtered by a pair of external capacitors for noise and ripple rejection.

IC2 uses crystal X1 (12MHz) to generate an internal clock which is then divided down to produce the sampling rate for both its ADC and DAC. These dividers are configurable and are controlled by microcontroller IC1.

Normally, a 12.288MHz crystal or similar would be required to get a sampling rate of 48kHz (by dividing by 256) but IC2 has a special "USB mode" designed to operate with a 12MHz clock, as used for USB communications. So we use a 12MHz crystal which is easier to get.

IC2 continuously samples the two analog input signals at pins 20 & 19 and converts the voltage levels at these pins to one of 65,536 possible values (2^{16}) at 20.8µs intervals. These values are serially streamed out in digital format from pin 6. Pins 2, 3 & 5 provide the clock signals required to interpret this data. Respectively, these are the master clock (MCLK, 12MHz), bit clock (BCLK, 3.072MHz = 48kHz x 2 x 32 bits) and left/right sample clock (LRCK, 48kHz).

The master clock is normally used to synchronise multiple digital audio devices in a system. In this case, we're simply using it as a reference clock for IC1, as it has a more precise frequency than IC1's internal oscillator.

The bit clock (BCLK) is at 64 times the sampling rate because the audio data is padded to 32 bits per channel. We're only using 16 bits per channel so half the time, this output will be zero (low) but the CODEC can be configured for 24-bit operation too, hence the higher clock rate. This clock is used by the micro to determine when a new data bit appears at the ADCDAT output.

The left/right sample clock indicates the start of a new value being transmitted on ADCDAT, as well as allowing the micro to determine which channel this value is for (low = right, high = left). Since this changes twice for each sample, the frequency of this signal equals that of the sampling rate, ie, 48kHz.

After receiving this data and delaying it for the appropriate amount of time, IC1 sends it back verbatim to IC2's pin 4, the DAC input data pin. The same clocks (ie, BCLK and LRCK) are used to time this data and thus the DAC and ADC sampling rates are locked together.

IC2's internal DAC then converts the received data to voltages on pins 12 & 13 (LOUT and ROUT respectively). These signals are AC-coupled using 1µF capacitors and DC-biased to ground using 47kΩ resistors. The 100Ω series resistors isolate any cable or load capacitance from IC2's internal op amp buffers.

From there, the signals then pass to the output at 6.35mm jack socket CON2. As explained, IC2 runs off 3.3V so the maximum output signal level is limited to around 1V RMS (2.828V peak-to-peak). This is sufficient to drive virtually any amplifier or mixer.

Note that the WM8731 codec has a "pass-through" mode whereby a direct analog connection is made from pin 20 (LLINEIN) to the analog buffer feeding pin 12 (LOUT) and similarly, from pin 19 (RLINEIN) to pin 13 (ROUT). We take advantage of this if the delay pot is set at minimum; in this case, there is essentially no delay and the distortion and noise from the unit drop too.

Microcontroller

As noted above, we chose the PIC32MX470F512H for a number of reasons. It is one of the latest PIC32 chips and as such it has two enhanced SPI peripherals which directly support all the common digital audio formats, including I²S, left-justified, right-justified and DSP modes. The WM8731 CODEC supports all these modes and we are using left-justified

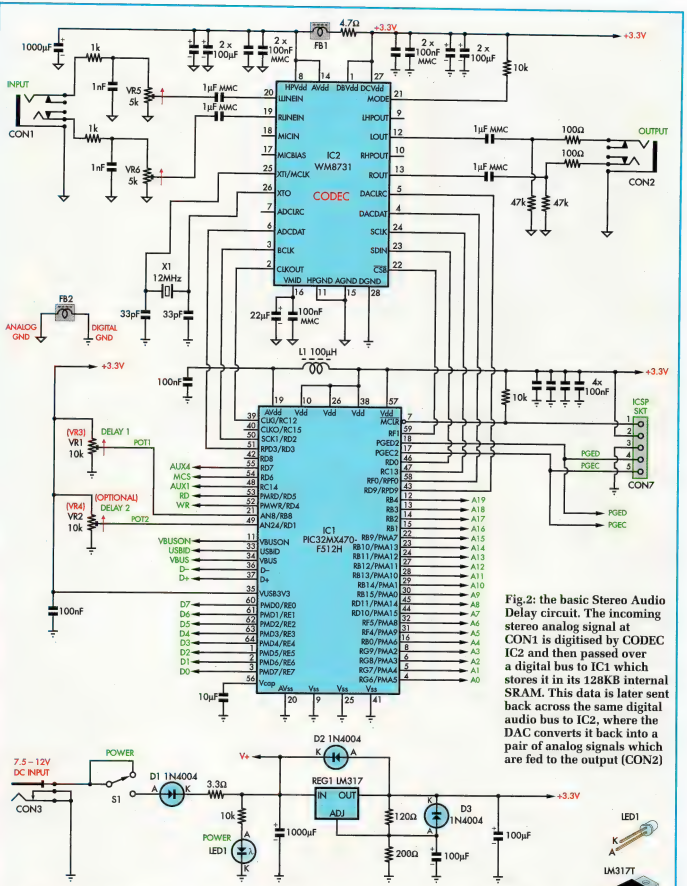


Fig.2: the basic Stereo Audio Delay circuit. The incoming stereo analog signal at CON1 is digitised by CODEC IC2 and then passed over a digital bus to IC1 which stores it in its 128KB internal SRAM. This data is later sent back across the same digital audio bus to IC2, where the DAC converts it back into a pair of analog signals which are fed to the output (CON2)

SC 120713 AUDIO DELAY FOR PA SYSTEMS

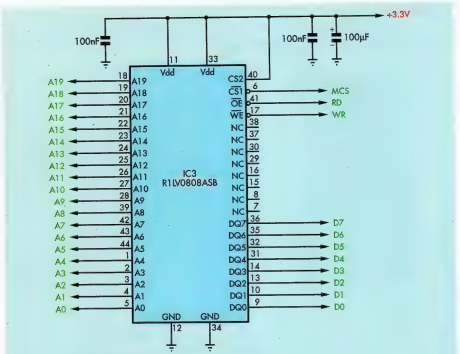


Fig.3: adding a Renesas R1LV0808ASB 1MByte SRAM chip allows the delay to be increased from a maximum of 640ms up to a maximum of six seconds. It runs from the same 3.3V supply as IC1 and is driven by the Parallel Master Port (PMP) memory interface in the PIC32.

mode as this allows us to set up the SPI peripheral to ignore the 16 trailing zeros for each sample.

This PIC32 chip also has four very flexible DMA (direct memory access) units. These are used to copy data between other peripherals and/or RAM simultaneously while the processor is busy doing something else.

In fact, they are so flexible that for a simple stereo delay, we just need to set up two DMA channels, one to read data from the CODEC and place it into a RAM buffer and another to read from a different location in that RAM buffer and send it back to the CODEC. The CPU can then go into idle mode while the DMA and SPI units do all the actual work! The processor core only needs to wake up periodically to check if the delay has been changed via the adjustment pot (using an interrupt request [IRQ]) and if necessary, adjust the DMA memory pointers to suit.

The main delay adjustment pot is wired to analog input pin 21 of IC1 (AN8). Normally, this is a multi-turn trimpot so that the delay can be preset but in some cases, it may be desirable to have an externally accessible knob and so 9mm pot VR3 can be fitted instead.

Provision has also been made for a second delay adjustment pot (VR2 or VR4). This allows the unit to provide two separate delays of the same mono signal and the delays can be set independently. This could be useful for a PA system where the speakers are placed far apart.

IC1 can detect whether VR2 or VR4 is installed since it has weak pull-up and pull-down current sources/sinks on every I/O pin which can be individually enabled or disabled (+250/-50µA). IC1 turns on the pull-up and pull-down currents alternately and measures the change in voltage on that pin.

Without VR2/VR4, the voltage difference will be nearly the supply voltage, ie, 3.3V. If either pot is installed, the change will be much less and so the unit knows to operate in dual mono delay mode.

The MCLK signal from IC2 goes to pin 39 of IC1, which is the clock input (OSCI), while the digital audio data (BCLK, DACDAT, DACLRC & ADCDAT) connects to pins which are routed to IC1's internal SPI/digital audio peripheral #1. This requires the bit clock to be connected to pin 50 but the other signals can go to one of several pins and are routed via its "Peripheral Pin Select" digital multiplexer.

The rest of the components surrounding the microcontroller are various power supply bypass capacitors, including a 10µF capacitor at pin 56 (VCAP) which is required to filter the 2.5V core supply. This is derived from the 3.3V rail by a low-dropout regulator within IC1. There is also provision for CON7 which is a 5-pin in-circuit programming header (ICSP), with a 10kΩ pull-up resistor for MCLR-bar (pin 7) to prevent spurious resets.

IC1 has a separate analog supply pin (pin 19, AVdd) for its ADC and a 100µH axial inductor is used to filter this supply. This ADC is used to sense the positions of VR1-VR4 by measuring the voltage at their wiper(s).

At the time of writing, the PIC32MX470 is so new that it is only available as engineering samples but production chips should be available by the time you read this. As usual, pre-programmed chips will be available from the Silicon Chip Online Shop.

Optional memory expansion

Virtually all of IC1's 128KB internal RAM is dedicated for use as a delay buffer and should be sufficient for most applications. But if a longer delay is required, IC3 can be fitted as mentioned above (see Fig.3). This is a Renesas R1LV0808ASB 1MByte SRAM chip. It runs from the same 3.3V supply as IC1 and its memory is arranged as 8 bits x 1048576 (2^{20}). This is driven by the Parallel Master Port (PMP) memory interface in the PIC32.

The PMP on this PIC32 has 16 address lines (PMA0-15), eight data lines (PMD0-7) and read/write strobe pins PMRD/PMWR. These are connected to IC3's A0-15 address lines (in no particular order), DQ0-7 bidirectional data lines, OE-bar (output enable) and WE-bar (write enable) respectively. The PMP can be driven by one or more DMA channels to allow copying between internal and external RAM while the processor is otherwise occupied.

Since a 1MB 8-bit SRAM requires 20 address lines and IC1 only has 16, the other four are driven by GPIO (general-purpose input/output) pins 12-15 (RB1-RB4). Thus, the Parallel Master Port can read or write blocks of 64KB of memory (2^{16}), with the four GPIO pins selecting one of 16 different 64KB blocks to access at any given time.

Besides the power supply pins

Parts List

1 double-sided PCB, coded 01110131, 148 x 80mm
1 ABS plastic instrument case, 155 x 86 x 30mm (Altronics H0377)
1 set front and rear panel labels
4 No.4 x 6mm self-tapping screws
1 12MHz HC-49 crystal (X1)
1 100µH axial RF inductor (L1)
1 10kΩ multi-turn vertical trimpot (VR1) OR 1 x 10kΩ 9mm horizontal potentiometer (VR3)
2 5kΩ horizontal mini trimpots (VR5,VR6)
2 6.35mm PCB-mount stereo switched jack sockets (CON1,CON2) (Jaycar PS0195, Altronics P0099 or P0073)
1 5-way pin header, 2.54mm pitch (CON7)
1 PCB-mount SPDT right-angle toggle switch (Altronics S1320)
1 DC plugpack, 7.5-12V, 100mA+
2 4mm ferrite suppression beads
1 PCB-mount switched DC socket to suit plugpack
1 M3 x 6mm machine screw and nut

Semiconductors

1 PIC32MX470F512H-I/PT 32-bit microcontroller programmed with 0111013A.hex (IC1) (available from Silicon Chip Online Shop)
1 WM8731SEDS or TLV320AIC23BIPW 24-bit 96kHz stereo CODEC (IC2) (element14 1776264)
1 LM317T adjustable regulator (REG1)
1 3mm blue LED (LED1)
3 1N4004 diodes (D1-D3)

Capacitors

2 1000µF 25V electrolytic
6 100µF 16V electrolytic
1 22µF 16V electrolytic
1 10µF 6.3V 0805 SMD ceramic
4 1µF 50V monolithic ceramic
11 100nF 6.3V 0805 SMD ceramic
2 1nF MKT
2 33pF ceramic disc

Resistors (0.25W, 1%)

2 47kΩ	1 120Ω
3 10kΩ	2 100Ω
2 1kΩ	1 4.7Ω 0.5W 5%
1 200Ω	1 3.3Ω 0.5W 5%

Extra parts for longer delay

1 R1LV0808ASB-5SI 8MBit 3.3V SRAM (IC3) (element14 2068153)
1 100µF 16V electrolytic capacitor
2 100nF 6.3V 0805 SMD ceramic capacitors

Extra parts for dual mono delay

1 10kΩ multi-turn vertical trimpot (VR2) OR 1 x 10kΩ 9mm horizontal potentiometer (VR4)

(which are bypassed with one electrolytic and two ceramic capacitors), the only remaining pins on IC3 are two chip select lines, CS1-bar and CS2. With CS2 permanently tied to +3.3V, CS1-bar controls whether IC3's interface is active and this is driven by GPIO pin 54 (RD6) of IC1 (active-low).

IC1 can detect whether IC3 is present simply by attempting to use it. With weak internal pull-downs enabled on the data bus, it will simply read zeros if IC3 is absent so we just need to do a test write to verify that it is connected and operating normally. If so, the delay adjustment range is set as 0-6s rather than 0-645ms.

Note that when using a RAM chip such as this, the order in which the data and address lines are connected doesn't matter. All that really matters is that when you write data to a particular address and then read that same address later (ie, all the address lines are in the same state), you get the same data back. Any jumbling of the address or data lines in a write operation is automatically reversed during a read.

This is in contrast to DRAM (dynamic RAM), where the memory is broken up into rows and columns, and it's much faster to access data sequentially than at random. SRAM is more akin to a large register file and in general, performance is identical regardless of the address pattern used during read or write operations.

Power supply

Toggle switch S1 switches power, while diode D1 provides reverse polarity protection. A 3.3Ω resistor limits the inrush current and REG1 provides a regulated output of 3.15-3.55V (nominally 3.35V), programmed with the 120Ω and 200Ω resistors. Diodes D2 & D3 protect REG1 against its input being suddenly shorted (however unlikely that is), while the capacitor at D3's anode improves high-frequency supply ripple rejection.

Blue LED1 is the power indicator and its current-limiting resistor is used to run it at 0.4-0.8mA, depending on the incoming supply voltage.

As well as the aforementioned supply bypass capacitors for microcontroller IC1 and optional SRAM IC3, there are also a number of bypass capacitors for IC2. Each of its various supply pins has a 100nF ceramic and 100µF electrolytic capacitor to ground. There is also a low-pass filter for its analog supply pins, to reduce the amount of supply noise that might be coupled from the digital circuitry. This is necessary to get good analog performance, especially for the ADC.

This filter consists of a 4.7Ω resistor with a ferrite bead over one of its leads, in series between the digital and analog +3.3V supplies, with a 1000µF filter capacitor for the analog supply. There is also a ferrite bead on the wire connecting the analog and digital grounds together.

Software

While the software to implement the delay function is not overly complex, there is still quite a bit going on. As usual, the source code will be available for download from the Silicon Chip website (free for subscribers, or for a small fee).

Most of the complexity resides in the "drivers" which must stream digital data between the microcontroller and CODEC and between the microcontroller's internal RAM and the external SRAM chip. Circular buffering is used to allow for continuous recording and playback – for details, see the article on the SportSync Audio Delay Module (May 2011).

Construction

All the parts mount on a double-sided PCB coded 01110131 and measuring 148 x 80mm. This fits into a snap-together ABS plastic instrument case measuring 155 x 86 x 30mm.

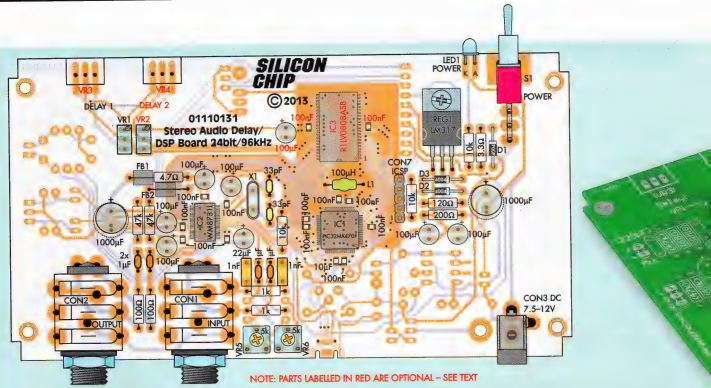


Fig.4: follow this parts layout diagram to build the PCB, starting with the SMD ICs and the SMD capacitors. The parts labelled in red are optional. Install SRAM chip IC3 only if you need a delay that's longer than 640ms and install VR2 (or VR4) if you want a dual channel delay unit with independently adjustable delays.

Fig.4 shows the parts layout on the PCB. Don't worry about the unpopulated pads; as stated above, they are there to accept extra circuitry to be described in the future.

Start the assembly by fitting the SMD ICs. IC1 and IC2 are required while IC3 (the SRAM chip) is optional. They are each fitted in more or less the same manner, as described below. Note that IC1 and IC2 have very closely spaced pins (about 0.5mm apart) but if you are careful, it's possible to hand solder these parts reliably.

Begin by placing the IC to be installed alongside its pads and identify pin 1. In each case, there should be a small dot or depression in one corner (you may need to view the part under a magnifying lens and a strong light to spot it). This must line up with the dot and pin 1 marking on the overlay diagram and this should also be shown on the PCB silkscreen printing.

Check that the part is the right way around, then apply a very small amount of solder to one of the corner pads. If you are right-handed, it's easiest to start with the top pad on the righthand side. If you are left-handed, start with the top pad on the left side. Avoid getting any solder on the adjacent pad.

That done, pick up the IC with a fine-tipped pair of angled tweezers and while heating the solder pad, gently slide it into place. Don't take too long doing this; if you heat the pad too much it could lift so after a few seconds, if it isn't in place, lift off and wait for the PCB to cool down before trying again. Once you have placed it, check the part's alignment under a magnification lamp or similar. All the pins must be accurately centred over their respective pads.

If they aren't, don't panic; it's just a matter of re-melting the solder on that one joint and carefully nudging the IC in the right direction. You might get it right first time or it may take several attempts to get it in place, the goal being to eventually get it properly aligned without spreading solder onto any other pins or pads and without heating the PCB or IC enough to damage them.

If you do get some solder on the adjacent pin, it's still possible to adjust the position but you will now need to heat both pins to get it to move. Take care though, because if three or more pins end up with solder on them, you will likely need to remove the part, clean up the pads using solder wick and then start again.

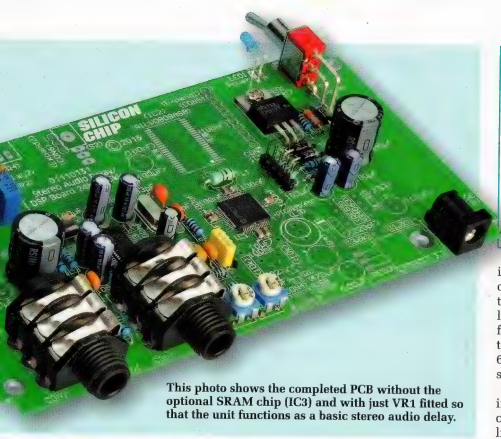
Once the part is in place, solder the diagonally opposite pin, then re-check the alignment under magnification as it may have moved slightly. If it has, you can reheat this second pad and gently twist the IC back into alignment. Once you're happy, solder the rest of the pins but don't worry too much about bridging them with solder (it's almost impossible to avoid). Remember to refresh that first pin you soldered.

Once all the pins have been soldered, spread a thin layer of flux paste along all the pins and gently press down on them with solder wick to suck up the excess solder. If done correctly, this will leave you with neatly soldered pins and no solder bridges. Go over all the pins once with the solder wick, then check under a magnifier for any remaining bridges. If there are any, add a dab of flux paste, then go back over them with the solder wick.

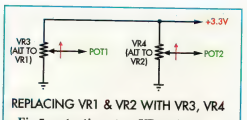
Once that IC is in place, you can repeat the above procedure until all the SMD ICs have been fitted.

By the way, rather than hand-solder these parts, you could use a home reflow oven (as described in Silicon Chip magazine in March 2008). However, we realise that most constructors won't have such a set-up and hand soldering is quite straightforward provided you follow the above procedure and have a good magnifying lamp and a fine-tipped soldering iron.

Once all the ICs are in place, follow with the SMD ceramic capacitors, using a similar procedure; ie, add solder



This photo shows the completed PCB without the optional SRAM chip (IC3) and with just VR1 fitted so that the unit functions as a basic stereo audio delay.



REPLACING VR1 & VR2 WITH VR3, VR4

Fig.5: potentiometers VR3 & VR4 can be installed instead of VR1 & VR2 if you want the delays to be externally adjustable (refer to the text for the various options). Don't install both VR1 & VR3 or both VR2 & VR4.

Capacitor Codes

Value	µF Value	IEC Code	EIA Code
1µF	1.0µF	1u	105
1nF	0.001µF	1n	102
33pF	NA	33p	33

to one pad, then heat this solder and slide the part into place before soldering the other pad and refreshing the initial joint. Be careful not to get the SMD capacitors mixed up.

In each case, wait about 10 seconds after soldering the first side of the capacitor before applying solder to the other side. This is necessary because the solder joint can remain molten for quite some time. If you try to solder the opposite pad too early, the capacitor will move out of alignment and it's frustrating trying to re-align capacitors when this happens.

Take care also not to short any IC pins when soldering in the SMD capacitors. They are located close to the ICs for performance reasons.

Through-hole parts

Proceed now with the low-profile components such as the resistors and diodes. Be sure to slip a ferrite bead (FB1) over one of the 4.7Ω resistor's leads before soldering it in place. It's best to check each resistor value with a DMM before fitting it as the colour bands can be difficult to read. The diodes are all the same type and all have their cathode bands facing to the top or righthand edge of the board.

In the case of FB2, slip the bead over a resistor lead off-cut and then solder it to the board as shown in Fig.4. You can also mount axial inductor L1 at this time. Follow with REG1; bend its leads down about 6mm from its body, feed them through the PCB holes, fasten its tab to the PCB using an M3 x 6mm machine screw & nut and then solder and trim the leads.

The horizontal trimpots can go in next, followed by the MKT and ceramic capacitors (disc and monolithic multilayer) and then pin header CON7 (not required if you have a pre-programmed microcontroller). That done, solder DC socket CON3 in place, followed by either VR1 or VR3 (to externally adjust the delay) but not both.

In addition, you can optionally fit VR2 or VR4 (but not both). As mentioned earlier, if either VR2 or VR4 is fitted, the unit will operate as two separate mono delay channels.

Now fit crystal X1 and the electrolytic capacitors, taking care to ensure that the latter are correctly orientated. Follow with power switch S1 and the blue power LED (LED1). This LED should have its leads bent at right angles 4mm from the base of the lens and then soldered so that the centre of the lens (and thus this short lead section) is 6.5mm above the top surface of the PCB.

This aligns the centre of the LED

Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	3	10kΩ	brown black orange brown	brown black black red brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	1	200Ω	red black brown brown	red black black black brown
❑	1	120Ω	brown red brown brown	brown red black black brown
❑	2	100Ω	brown black brown brown	brown black black black brown
❑	1	4.7Ω	yellow violet gold brown	yellow violet black silver brown
❑	1	3.3Ω	orange orange gold brown	orange orange black silver brown

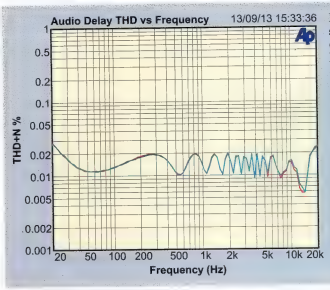


Fig.6: this graph shows that the delay unit should have little impact on sound quality, even when used with high-quality PA system (input signal level is 1V RMS). The 'oscillation' between 0.01% and 0.02% is due to the beat products of the 48kHz sampling rate and the input signal frequency (this is a form of aliasing).

with the centre of the switch. When bending the LED's leads, pay attention to the "A" and "K" markings on the PCB as the longer (anode) lead must be soldered to the anode pad. You can accurately set the height of the LED by cutting a 6.5mm wide cardboard spacer and pushing the leads down onto this.

The assembly can now be completed by soldering jack sockets CON1 and CON2 in place. Note that if you are using the type with six pins, you will also have to file or cut down the tall, rounded pieces of plastic just behind the screw threads (see photos), to prevent them from later fouling the case.

Checking it out

If you purchased a blank PIC32 chip, program it now (or purchase a programmed chip from the SILICON CHIP Online Shop). Complete kits will also come with a programmed chip.

The circuit can be powered from a PICkit3 programmer at 3.3V. In fact, the whole unit will operate normally from this supply so you can test the audio signal path immediately after programming the chip.

If you don't have a PICkit3, you will need to power the unit from a 7.5-12V DC plugpack. In this case, connect a voltmeter across the 3.3Ω resistor next to D1. Small alligator clip leads (or other test probe clips) are very useful for this purpose, as you can switch the unit on while watching the meter reading and switch it off immediately should the voltage across this resistor rise too high.

Expect a reading in the range of 0.2-0.3V, depending on the exact resistor value and how you have configured the unit. Much less than 0.2V indicates that there is an open circuit somewhere while much more than 0.3V indicates a likely short circuit. If the reading is outside the expected range, switch off immediately and check for faults.

The most likely faults would be one or more pins on an SMD chip bridged to an adjacent pin or not properly soldered to the PCB pad. Other possible faults include incorrect device orientation (primarily ICs, diodes and electrolytic capacitors) or poor/bridged through-hole solder joints.

Assuming all is OK, feed a line level audio signal into the input and connect the output to an amplifier. You should hear clear, undistorted audio with no delay. You can then adjust the delay pot setting(s) and check that this operates as expected. A fully clockwise setting will give a delay of either 640ms (no SRAM fitted) or 6s (SRAM fitted).

If you know what signal level will be applied to the input when the unit is in use, you can adjust trimpots VR5 & VR6 to suit now. To do this, feed in a sinewave of the expected amplitude, then adjust these pots so that the outputs measure just under 1VAC. Any higher will lead to clipping and distortion. Ideally, you should calibrate them separately.

If you aren't sure of the input signal amplitude, you can wait until you get the unit "in the field" to set the level pots. One method is to turn them clockwise until clipping and distortion start, then back them off slightly. However, this does risk setting the level high enough for slight clipping to occur which may not always be obvious. If the input signal is under 1V RMS (0dBu = 0.775V RMS), then you can simply set them both fully clockwise.

If all else fails, simply set VR5 & VR6 half-way. The unit can then handle input signals up to about 2V RMS but if the signal level is significantly lower than this, the noise and distortion will be less than optimal.

Case preparation

The front panel of the case needs holes for the power switch and LED, while the rear panel requires holes for the two jack sockets and the DC power plug. The front and rear panel artworks (Fig.7) can be used as drilling tem-

Fig.7: these two artworks can be copied and used as drilling templates for the front & rear panels. They can also be downloaded as a PDF file from the SILICON CHIP website.

The PCB is fastened into the case using four self-tapping screws which go into integral pillars. Note that the front & rear panels are normally fitted after the lid has been fitted.

plates. These can also be downloaded from the SILICON CHIP website in a single PDF file (free for subscribers).

It's simply a matter of printing (or copying) the labels, then accurately taping them to the panels, drilling a pilot hole in the centre of each location indicated and then enlarging each to size using a tapered reamer. That done, remove the templates and de-burr the holes using a counter-sinking tool or oversize drill bit. Any adhesive residue can normally be cleaned up with methylated spirits.

Check that the holes are large enough by test fitting the panels to the bare PCB. A new set of panel labels can then be printed onto photographic paper, attached to the panels using silicone adhesive and the holes cut out using a sharp hobby knife.

The assembly can now be completed by screwing the PCB to the bottom of the case using four No.4 x 6mm self-tapping screws, then placing the lid on top and snapping the front and rear panels on. If you have trouble fitting the panels over the connectors, enlarge the offending holes slightly. Note that the DC power socket is recessed; most DC power plugs are long enough to fit through the rear panel.

Using it

All that's left is to install the unit in its intended application and set the required delay. For PA systems, this can be a simple trial-and-error process whereby you incrementally increase the delay to get the best overall intelligibility at various points in the hall (or venue).

A similar procedure will be required where the unit is used to provide two separate delays.

Once adjusted, you can determine what the delay is actually set to by measuring either the frequency or the duty cycle at pins 4 & 5 of CON7. Even if the pin header is not fitted, you can simply "poke" probes into the plated PCB holes.

A PWM signal is provided at each of these pins and its frequency in Hz is equal to the set delay in milliseconds (DC = no delay). The duty cycle varies from 0-99%, with 99% indicating maximum delay (ie, 0.64s or 6s, depending on whether IC3 is fitted).

If the unit is set up for dual mono delays, measure pin 4 to determine the left channel delay and pin 5 the right channel delay. Note that the accuracy of these readings depends on the exact frequency of crystal X1.

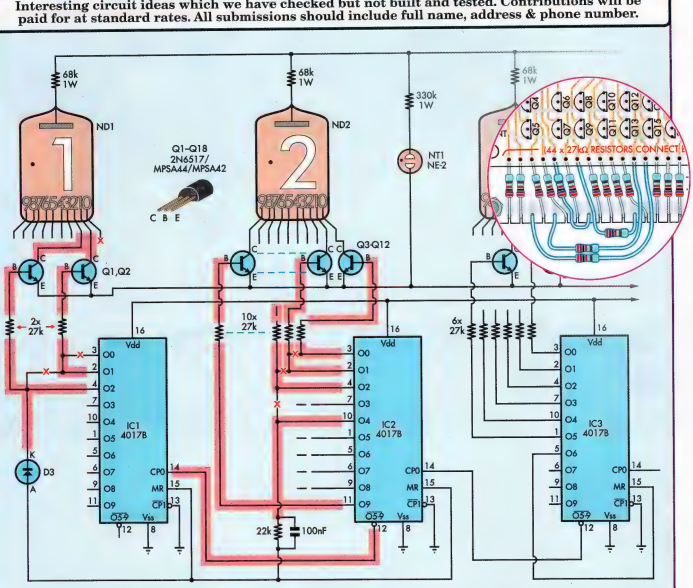
What's coming

That's all there is for the delay function. In the next instalment, we'll show you how to use the same hardware for echo or reverb. These functions are especially useful when used in conjunction with a microphone (for vocalists) or an electric guitar.

As such, we'll show you how to wire the unit up to a pedal, so that the effect can be switched on and off easily. We'll also show you how to reconfigure the unit to run from a 5V supply, in case you want to power it from a computer USB port or similar. SC

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



24-hour mode for Nixie Clock

The popular Nixie Clock presented in the July & August 2007 issues of SILICON CHIP displayed the time in 12-hour mode but it is a relatively simple modification to make it work in 24-hour mode. The above diagram shows the relevant part of the circuit and the changes are high-lighted by the pink lines. The connections that have to be cut are shown with a red "X".

Briefly, it involves changing the connections to the driver transistor for the "Hours x 10" digit (ND1) and changing connections to the 4017B decade counters IC1 & IC2. These counters will now count to 24 rather than 12.

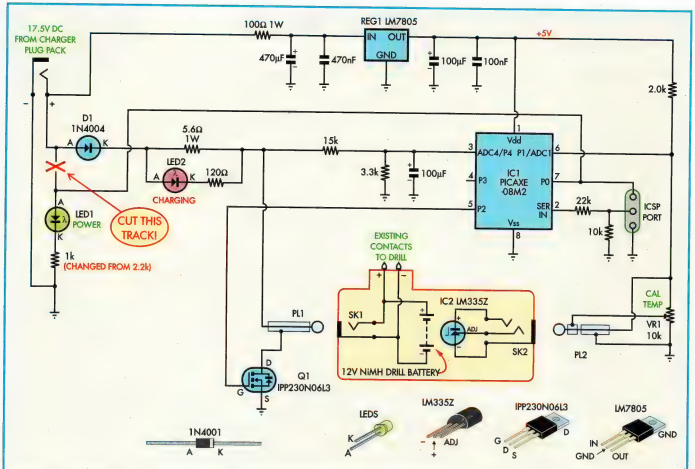
To explain further, the connection to pin 3 of IC1 needs to be disconnected and then connected to pin 4. Diode D3 needs to be relocated from the top of the board to the underside, with its cathode connected to pin 4 of IC1.

Transistor Q1's collector is disconnected from the "0" on Nixie ND1 and connected to switch the "2" on and off.

The track from pin 14 of IC1 to pin 11 of IC2 must also be cut. Pin 14 of IC1 is then connected to pin 12 of IC2 using insulated wire (note: the original circuit diagram incorrectly showed this already being the case).

A few of the 44 resistors that connected between the two boards along the front face need to have one end moved to a different pad, as shown on the overlay section. Four of these resistors will need heatshrink over them, to prevent them from shorting to other resistors that they cross over. These resistors will also need to be replaced with new ones as the cut leads will be too short for relocating.

Dennis Mulheron, Panania, NSW. ($50)



Intelligent drill battery charger

This charger was devised after the battery pack in a cordless drill had to be replaced after very little use. The factory charger was very basic and had no means of detecting "end of charge" for the NiMH battery pack. Hence, the existing charger was modified by incorporating a PICAXE08M2 microcontroller, IC1.

It's powered by a 17.5V 400mA plugpack which provides a full-wave rectified AC voltage of about 24V peak. This charges the battery pack via a series diode (D1) and 5.6Ω resistor to give a charging current of about 280mA, which is roughly the C/10 rate for the replacement cells.

The PICAXE08M2 senses the temperature of the battery via an LM335Z sensor which is like a zener diode with its reverse breakdown voltage directly proportional to the absolute temperature. The reverse breakdown voltage increases at a rate of 10mV/K, so that at 25°C (298K) its reverse breakdown voltage is 2.98V.

The LM335Z is biased into reverse breakdown by the 2.0kΩ resistor and this voltage is read at pin 6 of IC1. To sense temperature accurately, the LM335Z must be in close contact with one of the batteries in the pack. I put it in contact with the negative terminal of one of the cells, with some thermal heatsink paste to assist with heat transfer. A stiff piece of insulated wire was soldered to the negative terminal and used as a clamp to hold the LM335 in place.

The LM335 connects to the battery pack via a 3.5mm stereo socket (SK2). VR1 is used to calibrate the device, as follows: (1) note the battery temperature on a mercury thermometer; (2) convert this to absolute temperature by adding 273 and dividing the result by 100 (eg, 2.93 for 20°C); and (3) apply power and adjust VR1 to give 2.93V at pin 6 of IC1.

Pin 3 of IC1 monitors the battery voltage via the associated voltage divider resistors or, when a battery is not connected, it will sense the unloaded charging voltage from the charger. Because the latter is much higher than the former, this difference is used by IC1 to detect if a battery is present or not.

Normally, the battery would connect to its charger via the same contacts that it connects to the drill. I preferred not to connect to the charger this way but rather to make fresh flying leads and connect the charger to the battery via a DC power connector, PL1 and SK1. This allows Q1 to be in series with the negative lead. Q1 is controlled by pin 5 of IC1.

In use, IC1 senses if both a battery and temperature sensor are connected. It will not allow charging if the temperature is below 0°C or above 45°C. During charging, the temperature of the cells will rise

. . . continued on page 48

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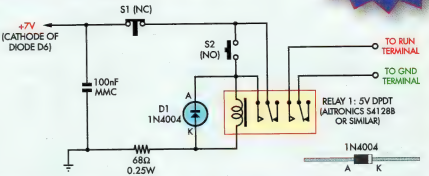
Peter Clarke is this month's winner of a $150 gift voucher from Hare & Forbes

Fail-safe starter for Induction Motor Speed Controller

The Induction Motor Speed Controller (SILICON CHIP, April & May 2012) can be built to serve two broadly different purposes. The most popular has been as a pool pump controller to reduce overall energy usage and the more specialised use has been as a speed controller for machinery such as lathes.

This latter application involves the RUN input which is connected to the GND terminal via a toggle switch (see page 76, May 2012). If this switch is closed, the motor runs and when the switch is off, the motor stops. But if the motor is running and a blackout occurs, the motor will restart when power is restored. This could be dangerous or undesirable since it could happen at any time. This fail-safe starter circuit prevents that from happening.

The circuit is powered from the 7V supply which feeds the cooling fan and REG1 in the Induction Motor Speed Controller. It runs a 5V



Telecom relay with DPDT contacts (eg, Altronics S-4128B) which has contacts rated for 2A. The relay is powered via a 68Ω 0.25W resistor.

The +7V rail is obtained by running a lead to diode D6's cathode, while the earth connection can be made at diode D8's anode. **Make sure that neither these leads nor any other part of this fail-safe circuit can come into contact with the high-voltage circuitry in the Induction Motor Speed Controller.**

In use, normally-off (NO) push-button switch S2 is pressed to energise the relay and start the motor. One pair of contacts connects the RUN terminal to GND while the other pair provides self-latching for the relay. If a blackout occurs, everything stops and cannot start again when power restored unless switch S2 is pressed. To stop operation, normally-closed (NC) pushbutton switch S1 is pressed to de-energise the relay.

Peter Clarke,
Woodcroft, SA.

Intelligent drill battery charger – continued from page 47

only gradually. When the cell is fully charged, the more rapid temperature rise of the cells is detected by IC1 which then stops the charging process.

The temperature is checked every five minutes and if a temperature rise of three or more "ADC units" is detected, charging will stop. This figure was arrived at empirically and will depend on the particular charger being used. My charger delivers a slow charge and so the temperature rise is not as rapid as would occur if a fast charger were used. Some experimentation may be required if your charger delivers a significantly different charging current.

Ultimately the choice is a compromise. Set it too high to squeeze in as much charge as possible and you risk the temperature rise not being achieved. This could result in overcharge, as the program will default to a 10-hour charge time. If set too low, the cells will not be charged to the maximum possible but otherwise no damage will be done to the cell. Note that this charger should also be suitable for use with Nicad cells.

The software *nimhchargersc.bas* is on the SILICON CHIP website.

Jack Holliday,
Nathan Qld. ($70).

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$209.00

HDR Time Lapse Professional Video Recorder

Features an advanced HDR image sensor allowing the capture of excellent videos in harsh light without washing out the image. Includes a 1.44" viewfinder for setting the perfect angle. Includes 4GB SD card which can capture up to 30,000 images.

- 1.44" TFT LCD
- Size: 105(H) x 64(W) x 45(D)mm

QC-8038

NEW

$449.00

BIRTHDAY BONUS!

Ask for your FREE Jaycar Cooler Bag when you spend $50 or more from our Birthday Flyer.

HB-5005

Cat III True RMS DMM with Temperature

A powerful true RMS multimeter that includes non-contact voltage testing, backlit LCD, and a carrying pouch.

- 4000 count
- Powered by 1 x 9V battery (included)
- Size: 138(L) x 68(W) x 37(D)mm

QM-1551

NEW

$59.95

10W Rechargeable Worklight

Uses 10W LED rechargeable worklight with a handy metal clamp for quickly turning a mobile light into a fixed position light. Recharge with the supplied mains or car cigarette lighter charger.

- IP65 rated
- 500 Lumen
- Size: 119(H) x 110(L) x 117(D)mm

SL-2791

NEW

$74.95

DUE EARLY NOVEMBER.

GPS Data Logger Kit

Records where your car or boat has travelled over time. Playback on software such as Google Earth. Kit supplied with silk-screened PCB, enclosure with label, pre-programmed PIC, GPS module, and components.

- Records route, time and date onto an SD card (available separately)
- Records POI at the touch of a button
- 12VDC powered

KC-5525

NEW

$149.00

DUE END OF NOVEMBER.

Party Time at Jaycar

8" Active Subwoofer with Satellite Output

Incorporates 2 x 15WRMS audio output for satellite speaker connection for true 2.1 stereo performance. Housed in a black enclosure. Enhance movie audio and in-game gun battles.

- 8", 30WRMS
- Size: 350(L) x 260(W) x 315(H)mm

CS-2433

NEW

$149.00

2.1 Speaker Subwoofer Package

Combine our 8" subwoofer (CS-2433) and a pair of 2.5" cube speakers (CS-2431). Great for a home theatre or gaming console.

CS-2434

NEW

$169.00

To order call 1800 022 888

www.jaycar.com.au

Savings off original RRP

Jaycar Electronics
Better, More Technical

Test & Measurement

Non-Contact Thermometer with Temperature Comparison

An easy way to compare the temperature between surfaces. Simply point the thermometer at a surface and press the trigger to set a reference temperature. The device will produce an audible and visual warning if the temperature has exceeded or dropped below the reference point.

- Temperature: -50°C ~ 260°C (-58°F ~500°F)
- 20:1 distance to spot ratio
- Size: 170(H) x 125(D) x 67(W)mm

QM-7211

$119.00

Professional Wind Speed Meter/Thermometer

Capable of measuring wind/airflow parameters at the same time as monitoring temperature.

- Metres/sec; km/hr; feet/min; miles-per-hour; knots
- Cubic metres/minute; cubic feet/minute
- Air temp, 0-50°C (0.1°C resolution)
- Vane impeller ball bearing mounted
- 1m vane probe lead
- High accuracy

QM-1646

NEW

$99.00

Cat III 4000 Count Autoranging DMM

An accurate and easy to use autoranging DMM. Select the parameter required and the meter chooses the appropriate display range. Features temperature, capacitance, data hold and auto power off plus a backlit display for measuring in dark places.

- 4000 count
- Size: 150(H) x 70(W) x 50(D)mm

QM-1327 **WAS $34.95**

$29.95

SAVE $5

Digital Light Meter

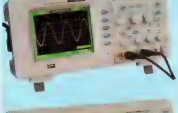
A handy lightmeter for photography, lab work, architectural, engineering and construction. Measure incident light in 4 ranges from 0.01 to 50,000 lux. Separate Photo Detector.

- 12V
- 2000 count
- 188mm long

QM-1587

$49.95

Digital Storage Oscilliscopes



- USB interface
- Includes 2 x 10:1 probes, EasyScope software and USB cable

25MHz Dual Channel

Ideal for the advanced hobby user or technician and is particularly suited to audio work. See online for more details.

- 145mm colour TFT LCD
- Size: 310(W) x 150(H) x 130(D)mm

QC-1932 **WAS $499.00**

$449.00

SAVE $50

100MHz Dual Channel with 7" Screen

Enhanced performance, professional level test instrument for the technician, design engineer or development laboratory. Includes a carry bag. See online for more details.

- 178mm colour TFT LCD
- Size: 340(W) x 150(H) x 110(D)mm

QC-1934 **WAS $899.00**

$849.00

SAVE $50

400A AC/DC Clampmeter

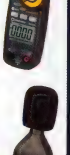
A quality, intermediate-level clampmeter with current ranges up to 400 amps AC and DC.

- 4000 count
- Data hold, non-contact voltage, relative measurement
- Autoranging
- Diode test
- Jaw opening 30mm
- Size: 198(H) x 66(W) x 36(D)mm

QM-1563 **WAS $119.00**

$99.00

SAVE $20



Digital Sound Level Meter

Measures sound levels between 30 to 130dB and can be set for fast or slow responses. Includes data hold and min/max functions, as well as tripod mount. Supplied with carry case, wind sock and battery.

- 210mm long

QM-1589

$99.00

3 in 1 Stud Detector with Laser Level

Indicates proximity when you are near a stud via its large LCD and shows a target graphic when you're spot on. The unit also features voltage detection and a built-in laser level.

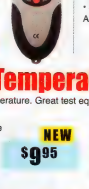
- 9V battery included
- Size: 180mm long

QP-2288

WAS $49.95

$39.95

SAVE $10



Roadies Cable Tester

Simply plug the cable under test and turn the rotary switch. The LEDs gives an instant go/no-go status of each conductor path in the cable. Suitable for any technician working with cables.

- Requires 1 x 9V battery
- Size: 190(L) x 98(W) x 35(H)mm

AA-0405

$49.95

Automatic Upper Arm Blood Pressure Monitor

This pressure-cuff unit fits on your upper arm. It will measure 30-280mm mercury, and 40-195 pulse.

- Displays date/time, systolic, diastolic and pulse rate
- Requires 4 x AA batteries
- Size: 125(L) x 83(W) x 153(H)mm

QM-7261

NEW

$59.95

Monitor Your Temperature

Quickly and easily checks body temperature. Great test equipment for the home.

Digital Thermometer

Features a soft flexible tip to measure temperature in a variety of places.

- Size: 130(L) x 25(W) x 15(D)mm

QM-7274

NEW

$9.95

Forehead Thermometer

Simply hold the probe end to the forehead and within 1 second a temperature reading will be returned.

- Size: 130(L) x 50(W) x 30(D)mm

QM-7271

NEW

$29.95

Ear Thermometer

Measures temperature via the ear canal - an accurate safe and non-invasive technique.

- Size: 155(L) x 35(D) x 33(W)mm

QM-7272

NEW

$34.95

QM-7272 shown

Note: This is not a medical diagnostic device and is intended to provide indicative readings only. It should be used in conjunction with advice from a doctor or other clinical professional.

Also available **Pill/Medication Container with Alarm**
QM-7237 $12.95

Tool Kits

Jaycar Electronics
Better. More Technical.

Long Bit Screwdriver Set

Comprised of a selection of popular slotted, Phillips, Star and TRI bits. Packed away neatly inside a handy storage case. See website for contents.

- 22-piece

TD-2114

$29.95

Gaming Console Tool Kit

Includes the tools required to open modern games consoles or handhelds to clean or repair them. See online for a full list of contents.

TD-2109 **WAS $29.95**

$24.95

SAVE $5

Portasol Pro Gas Soldering Tool Kit

This kit contains a Portasol Pro Piezo Gas Soldering Iron, cleaning sponge and tray, 2.4mm double flat tip, hot air blow, hot knife tip, hot air deflector and flame tip.

- Quality storage case

TS-1318

WAS $129.00

$99.00

SAVE $30

Limited stock. HURRY!

500W 240V Electric Drill

Suitable a variety of tasks around the house or on the job. Features a forward/reverse switch, lock setting, and moulded plastic grip. Will accommodate bits up to 10mm and includes a handy belt clip.

- Mains powered
- Cable length: 1.8m
- Size: 250(L) x 190(H) x 65(D)mm

TD-2493

NEW

$19.95

Automotive Crimp Tool with Connectors

The tool will cut & strip wire, crimp connectors and also cut a range of metric bolts. Every car enthusiast should have one of these.

- Includes male & female bullet & spade connectors + eyes and butt joiners.

TH-1848

$13.95

Goot Soldering Station

Precision, Japanese manufactured instrument with excellent temperature stability and anti-static characteristics. It has a digital temperature adjustment from 200 to 480˚C at 65W and a lightweight soldering pencil. See website or for full specifications.

- 70W, 24VAC
- Size: 146(L) x 115(W) x 98(H)mm

TS-1440 **WAS $299.00**

$229.00

SAVE $70

ABS Tool Cases

ABS Instrument Case

Ideal for professionals to carry around small sensitive devices including computer, medical, or engineering equipment.

- Black
- Lanyard included
- Size: 173(L) x 125(W) x 50(H)mm

HB-6389

NEW

$19.95

DUE EARLY NOVEMBER.

Waterproof ABS Cases - Black

Waterproof ABS cases for storing or transporting Smartphones, radios, delicate electronic devices and more.

- Waterproof
- Shockproof
- Lanyard included

HB-6421 $14.95
- Size: 182(L) x 120(W) x 42(H)mm

HB-6423 $19.95
- Size: 182(L) x 120(W) x 75(H)mm

HB-6425 $24.95
- Size: 655(L) X 482(H) X 495(H)mm

DUE EARLY NOVEMBER.

HB-6241 shown

NEW FROM $14.95

ABS Instrument Rolling Case

Ideal for the travelling professional.

- Retractable handle
- Built-in wheels
- Size: 530(W) x 355(D) x 225(H)mm

HB-6387

$175.00

LED Headband Magnifier

This magnifying headset leaves both hands free and can be worn over prescription or safety glasses. Ideal for jewellery, radio electronics, & camera repair etc.

- Adjustable head strap
- Built-in LED work light
- 1.5x, 3x, 8.5x or 10x magnification
- Requires 2 x AAA batteries

QM-3511

$29.95

Illuminated Gooseneck Magnifier

This handy hobbyist's magnifier has a 2 x main magnifier lens with 5 x insert lens and 2 LED lights, all mounted on a flexible arm. Can be free-standing or clamped to a surface up to 38mm thick.

- Requires 3 x AAA batteries

QM-3532 **WAS $29.95**

$19.95

SAVE $10

PCB not included

Universal Relay Wiring Kit with Switch

A universal relay wiring kit for fitting various 12V devices to your car. It is a complete "ready to use" harness with fused battery connections, horn relay, in-cabin toggle switch, and waterproof 2 pin connection.

- Max current rating: 7A (80W)

SY-4079

NEW

$29.95

Resistance Wheel

Great for experiments or selecting the best resistance for a circuit. Select from 36 values ranging from 5 ohms to 1M ohms.

- Comes complete with leads and insulated alligator clips
- Uses 0.25W resistor with 5% tolerance

RR-0700

$29.95

50x Magnifier to suit iPhone 4/5® + S3

Simply attach it to the back of your phone to see a greatly magnified view of objects.

- Size: 117(L) x 61(W) x 11(H)mm

QM-3516

$19.95

Jaycar Electronics
Better, More Technical

Party Time

Multicoloured LED Party or Stage Lighting Kit

This stage lighting kit features 4 extremely thin LED PAR lights with a stand extendable up to 1.8m, 3 modes of operation (DMX, Master/Slave and sound activation), RGB colour mixing and advanced LED technology. Each unit features 145 bright red, green and blue LEDs PAR CAN. Includes a light and stand carry bag plus a foot controller.

- DMX Channel: 13
- Mains powered
- Light carry bag: 700(L) x 390(W) x 200(H)mm

SL-3467 **WAS $399.00**

$349.00
SAVE $50

DMX LED Moving Head Spot Light

Compact, lightweight and cost effective. Integrates a user selectable 540° pan and 270° tilt, it has 9 gobos plus open and wheel spin effect.

- 15W RGBW LED light
- Fan cooled
- Built-in movement macros
- Mains powered
- Size: 249(H) x 173(W) x 173(D)mm

SL-3440 **WAS $299.00**

$259.00
SAVE $40

Blue Mini Spotlight with 3W Cree®

This ultra compact mini LED spotlights offer a super bright precision beam. The mounting bracket makes this unit suitable for stage lighting at parties or used on a rotating mirror ball.

- Mains powered
- Size: 56(Dia.) x 97(L)mm

SL-3471 **WAS $34.95**

$29.95
SAVE $5

LED Strobe Light

Features 74 super bright white LEDs with adjustable flash rate. Energy efficient and long lasting suitable for home parties.

- Mains powered
- Size: 140(L) x 120(Dia.)mm

SL-3464

$39.95

PAR 64 2 Channel DMX Spotlight

A lightweight, compact and cool-running blacklight PAR 64 spotlight with 3 operating modes: sound-active, automatic and DMX control. It features 177 UV emitting LEDs, brightness control, strobe effect and a built-in microphone.

- Mains powered
- Size: 240(W) x 200(H) x 310(D)mm

SL-3466 **WAS $119.00**

$99.00
SAVE $20

Home Theatre

Plasma/LCD TV Ceiling Mount Bracket

An innovative bracket that allows professional mounting of flat screen TVs hanging from a ceiling. The heavy duty 280x280mm ceiling mount plate will safely and securely hold the TV in place so people can comfortably view a program in a foyer, a medical waiting room, hallway, or at home.

- Tilt and rotate for maximum viewing flexibility
- Solid aluminium and steel construction
- Maximum load: 80kg
- Recommended screen sizes: 32" to 60"

CW-2855

NEW
$179.00

BE REWARDED for your love of electronics

As a way of saying thank you – everyday – we've put together a loyalty programme called Jaycar Rewards. It's for our regular customers who love DIY everything electronic!

The Jaycar Rewards programme will entitle you to accumulate one point with every dollar spent* at any Jaycar Store* and be rewarded with a $25 Rewards Cash Card once you reach 500 points.

Register online today by visiting

www.jaycar.com.au/rewards

*Conditions apply, company stores only and only available for retail transactions in Australia and New Zealand. See website for full terms and conditions.

Professional Vocal Dynamic Microphone

A top quality balanced mic suitable for singing and band work. Supplied with 3 pin Cannon lead and 6m cable.

- Type: Unidirectional balanced dynamic
- Impedance: 500 ohm

AM-4096

$39.95

Buy 2 for $65
SAVE $14.90

3 Channel Headphone Amplifier

This economy headphone amplifier is designed to allow up to three people to listen to the same music source on three separate sets of headphones.

- 3.5 stereo to 2xRCA adaptor included
- Size: 128(W) x 46(H) x 63(D)mm

AA-0400

$29.95

Also available
3 Channel Microphone Mixer AM-4220 $29.95

Multimedia Wallplates

Give your home theatre installation a neat finish with these handy wallplates. Simply run a pre-made cable within the wall cavity and plug it into the back of the wallplate.

- Size: 116(H) x 75(W) x 12(D)mm

VGA, PC Audio, and Composite Audio and Video
PT-0471 $24.95

VGA, USB, and Hi-Fi Audio
PT-0473 $24.95

HDMI, VGA, PC Audio, and Composite Video
PT-0475 $29.95

NEW FROM
$24.95

Audio Converters

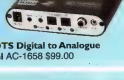
AC3 and DTS Digital to 5.1 Analogue Audio Converter

This converter will accept input via RCA coaxial, 2 x SPDIF, or 3.5mm stereo audio and output any of them to 5.1 channel analogue (6 x RCA).

- 24-bit Audio DSP

AC-1634

NEW
$119.00



Also available **AC3/DTS Digital to Analogue Converter 2 Channel** AC-1658 $99.00

Analogue to Digital Audio Converter

Accepts stereo audio input from 2 x RCA (red/white) leads and outputs to a high quality noise free digital format for connection to a modern sound system.

- Input: Stereo line in (dual RCA jacks)
- Output: S/PDIF TOSLINK optical & S/PDIF RCA coaxial
- Size: 80(L) x 70(W) x 27(H)mm

AC-1596

DUE EARLY NOVEMBER.

NEW
$79.95

4 Input HDMI Switcher

This versatile HDMI switcher allows you to expand your HDTV system and connect multiple devices such as game consoles or DVD players to a single HDMI input.

- HDMI 1.4a Compliant
- Supports 3D, HEAC, and CEC
- 4 x HDMI Inputs, 1 x HDMI Output
- Ethernet Port
- Size: 154(W) x 70(D) x 25(H)mm

AC-1619

$99.00

To order call 1800 022 888

www.jaycar.com.au

Savings off original RRP. Limited stock on sale items

Party Time

Jaycar Electronics
Better. More Technical

5 Channel DMX LED Light Controller

Creates colourful scenes and amazing lighting effects. Features six selectable modes with a combination of RGB colour mixing, fading, chasing and sound control.

- 9V plugpack included
- Size: 252(L) x 122(W) x 46(H)mm

SL-3423

$89.95

DMX Powered Laser Beam

Create lasers at your next party, concert, or stage production. This model features an XLR out plug that allows you to daisy-chain multiple units together for full DMX controlled ambience.

- Laser colour: red, green & yellow
- Sound control: Auto, DMX 512 (7 channels)
- Mains powered
- Size: 363(L) x 143(W) x 67(H)mm

SL-3451

$199.00

DJ Equipment

2 Channel MIDI Mixer with Virtual DJ Software

Mix, play and scratch your own MP3 tracks directly from your PC. The mixer sends MIDI data from the controller to your DJ software without the inconvenience of mouse control. It's a fully class-compliant USB MIDI device complete with Virtual DJ software.

- 2-deck controller
- Mix 2 flies in 1 controller
- USB powered
- Size: 358(W) x 260(H) x 45(D)mm

AM-4252 **WAS $249.00**

$229.00

SAVE $20

Naval Style Comms Speaker Gymbol Mount

NEW

This small but powerful unit delivers clear voice from either VHF, 27MHz or even HF communications receivers. Mylar speaker cone, gasketed bezel and IP65 entry cord.

- 4W, 2.25WRMS
- Naval style light grey
- Size: 66(L) x 66(W) x 55(H)mm

AS-3186

$24.95

Wireless Microphone System

A professional wireless VHF microphone system with enhanced signal reception. Includes 2 microphones, 1 wireless receiver, and plugpack.

- High-precision quartz crystal locked frequency
- Up to 80m range
- Size:195(L) x 145(W) x 42(H)mm

AM-4071 **WAS $69.00**

$49.00

SAVE $20

Lapel Mics to suit

Lapel Mic Channel A AM-4057
WAS $29.95 NOW $19.95 SAVE $10

Lapel Mic Channel B AM-4059
WAS $29.95 NOW $19.95 SAVE $10

OVER 20% OFF

Limited stock. Not available in all stores.

Laser Light Shows

Whether staging a dance club, house party, full pro DJ setup or stage production, laser light projectors help create the perfect atmosphere. They produce truly spectacular lighting effects with hundreds of twinkling and constantly moving laser lights.

Red & Green Mini Laser Show

Basic economy model provides red and green twinkle laser light display. Sound activated, auto or remote control with variable modulation. Manually controlled only.

- Mains powered
- Size: 270(L) x 215(W) x 115(H)mm

SL-3439 **WAS $99.00**

Limited stock. HURRY!

$89.00

SAVE $10

Red/Green Mini Laser Light Show with RGB LED

Features a full colour LED that adds vibrancy and substance to each laser pattern. Great for restaurants, foyers, or parties.

- Mains powered
- Size: 140(L) x 105(W) x 55(H)mm

SL-3453

Limited stock. HURRY!

$129.00

Green DMX Laser Show

It produces over 100 green patterns with sound activation or DMX master/slave control.

- Mains powered
- Size: 205(L) x 80(W) x 145(H)mm

SL-3436 **WAS $139.00**

Limited stock. Not available online.

$99.00

SAVE $40

Animation Green Laser Show

The unit comes with pre-programmed displays and characters, but with the use of ILDA (International Laser Display Association) software you can add PC control to create cartoon, letters, figures or other characters. Software is not included.

- ILDA software or DMX control
- Mains powered
- Size: 270(L) x 80(W) x 174(H)mm

SL-3438 **WAS $279.00**

Limited stock. Not available online.

$229.00

SAVE $50

2 Channel DJ Mixer

The ideal mixer to learn on. Two channels each with RCA inputs for CD or other line level source and a set of phono inputs.

- Level meters on each channel
- 2 band EQ on each channel
- Mic and headphone outputs
- Effects loop
- Line level preamp outputs
- Size: 330(W) x 22(H) x 102(D)mm

AM-4206 **WAS $149.00**

$129.00

SAVE $20

4" Communication Speaker

A powerful waterproof speaker to connect to CB radios and other communication devices for clearer audio reproduction.

- 15W, 10WRMS
- Size: 108(L) x 108(W) x 62(D)mm

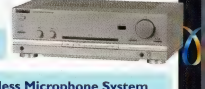
AS-3187

NEW

$29.95

Stereo Amplifier with Remote Control

Rated at a generous 100WRMS per channel and has a flat frequency response from 20Hz to 20kHz. Includes remote control to adjust input source, volume, etc.



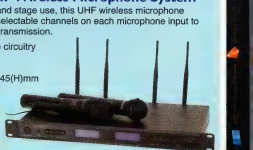
- 2 x 100WRMS
- Inputs for Tape, Tuner, AV1, AV2, CD, Phono
- Size: 420(W) x 135(H) x 214(D)mm

AA-0470

$169.00

Dual Channel UHF Wireless Microphone System

Suitable for professional and stage use, this UHF wireless microphone system features 16 user-selectable channels on each microphone input to provide interference-free transmission.



- Phase locked loop (PLL) circuitry
- Mains power supply
- 2 microphones included
- Size: 420(L) x 210(W) x 45(H)mm

AM-4120 **WAS $299.00**

$249.00

SAVE $50

Jaycar Electronics
Better, More Technical

Hardcore

PCB Essentials

Breadboard
- Mounted on a metal plate
- Rubber feet
- 1680 tie points
- 400 distribution holes
- 1280 terminal holes
- 3 banana terminals
- Board size: 130(W) x 178(H)mm

PB-8816

$39.95

Breadboard Jumper Kit

Specifically made for breadboards and consists of 70pcs of single core sturdy wire.

- 14 different lengths with 5 pcs each

PB-8850

$11.95

PCB Etching Kit
Use to etch a circuit board. See website for full product inclusion.

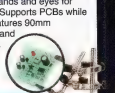
HG-9990 **WAS $27.95**

$19.95

SAVE $8

PCB Holder with Magnifying Glass
An extra pair of hands and eyes for those fiddly jobs. Supports PCBs while soldering etc. Features 90mm magnifying glass and two alligator clips.
- Size: 78(L) x 98(W) x 145(H)mm

TH-1983



$12.95

PCB not included

Service Aids

Adhesive Turbo Weld
An all-purpose formula that quickly and easily repairs objects made of metals, timber, ceramics, plastics, glass, rubber and much more.
- Non-toxic, colourless, ultra strong and versatile

NA-1524

NEW

$7.95

Isopropyl Alcohol Spray
Use to clean and prep surfaces, contact cleaning, stain removal etc. 99.8% concentration.

250mL Bottle
NA-1066 $8.95

300g Aerosol Can
NA-1067 $9.95

FROM $8.95

Electronic Circuit Board Cleaner
Dissolves flux residue and grime leaving the tracks and board spotless.
- CFC ozone safe

NA-1008

$11.50

Electronic Cleaning Solvent
Ideal to use on delicate electronic, electrical and mechanical assemblies.
- Fast drying and high purity

NA-1004

$11.50

10% OFF SELECTED FANS!

FROM $13.90

Mechanical Ventilation
Suitable for computers, office machinery, appliances, power untis, amplifiers etc. Can be mounted on suction or discharge side.
- Long life - 60,000 hours at 25˚C, 30,000 at 40˚C
- Ball bearing: 100,000 hours at 25˚C

12V Ball Bearing Fans		WAS	NOW	SAVE
97 x 94mm Blower Fan	YX-2532	$29.95	$26.95	$3.00
40mm - 3 Wire	XC-5054	$15.90	$13.90	$2.00
50mm - 3 Wire	XC-5055	$15.90	$13.90	$2.00
80mm - 2 Wire	YX-2513	$19.95	$17.95	$2.00
80mm - IP55	YX-2523	$24.95	$21.95	$3.00
120mm - Thin 2 Wire	YX-2518	$28.95	$25.95	$3.00
120mm - IP55	YX-2522	$36.95	$32.95	$4.00

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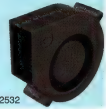
YX-2508



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KJ-8970

KJ-8972

240V 10A Deluxe Motor Speed Controller Kit

Ref: Silicon Chip Magazine April 2009

The deluxe motor speed controller kit allows the speed of a 240VAC motor to be controlled smoothly from near zero to full speed. The advanced design provides improved speed regulation & low speed operation. Also features soft-start, interferences suppression, fuse protection and over-current protection. Kit supplied with all parts including pre-cut metal case.

KC-5478

NOTE: Not for use with induction motors.

$99.95

Automatic Headlights Kit for Cars

Ref: Silicon Chip Magazine Oct 2013

Like modern cars, this kit will turn your car headlights on automatically if you forget to turn the lights on when it gets dark. It can also turn the lights off when you park to avoid a flat battery. See website for full features.

- Kit supplied with double sided, solder-masked and screen-printed PCB, die-case cast, buzzer and electronic components. Cabling not included

KC-5524

NEW $59.95

Speed Control Kit for Induction Motors

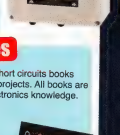
Ref: Silicon Chip Magazine May 2012

Control induction motors* up to 1.5kW (2HP) to run machinery at different speeds or controlling a pool pump to save money. Also works with 3-phase motors. Full form kit includes case, PCB, hardware and electronics. Soldering and construction required.

KC-5509

NOTE: *Does not work for motors with centrifugal switch

$249.00



Jacob's Ladder MK3 Kit

Ref: Silicon Chip Magazine Feb 2013

A spectacular rising ladder of bright and noisy sparks for theatre special effects or to impress your friends. This improved circuit has even more zing and zap than it's previous design from April 2007 and requires the purchase of a VS Commodere 12V ignition coil (available from auto stores and parts recyclers). Powered from a 12V 7Ah SLA or 12V car battery.

- Kit supplied with silk-screened PCB, diecast enclosure (111 x 60 x 30mm), pre-programmed PIC, PCB mount components and pre-cut wire/ladder

KC-5520

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Battery Saver Kit

Ref: Silicon Chip Magazine Sept 2013

Cuts off the power between the battery and load when the battery becomes flat to prevent the battery over-discharging and becoming damaged. Suits SLA, Li-ion, Li-Po and LiFePO4 batteries between 6 to 24V. Uses very little power (<5uA) and handles 20A (30A peak). Supplied with double sided, soldermasked and screen-printed PCB with SMDs pre-soldered (apart from voltage setting resistors) and components.

- PCB: 34 x 18.5mm

KC-5523

NEW $29.95

Theremin Synthesiser Kit MkII

Ref: Silicon Chip Magazine March 2009

Create your own eerie science fiction sound effects by simply moving your hand near the antenna. Easy to set up and build. Complete kit contains PCB with overlay, pre-machined case and all specified components.

- PCB: 85 x 145mm

KC-5475

$74.95

Speedo Corrector MkII Kit

Ref: Silicon Chip Magazine Dec 2006

When you modify your gearbox, diff ratio or change to a large circumference tyre, it may result in an inaccurate speedometer. This kit alters the speedometer signal up or down from 0% to 99% of the original signal. Kit supplied with PCB with overlay and all electronic components.

- PCB: 105 x 61mm
- Recommended box UB5 use HB-6013

KC-5435

$54.95

USB Power Monitor Kit

Ref: Silicon Chip Magazine Dec 2012

Plug this kit inline with a USB device to display the current that is drawn at any given time. Displays current, voltage or power, is auto-ranging and will read as low as a few microamps and upto over an amp. Kit supplied with double sided, soldermasked and screen-printed PCB with SMD components presoldered, LCD screen, and components.

KC-5516

- PCB: 65 x 36mm

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- Mains powered
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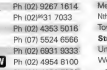

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SERVICEMAN'S LOG

Office computers can take some sorting out

Dave Thompson*

Because I no longer have employees, I have to be careful about the jobs I take on as I cannot leave the workshop during business hours. Sometimes though, I get talked into jobs that I would normally knock back but this one worked out well.

IT CAN BE a daunting task for a serviceman to set up a new office computer network from scratch. By the same token, it can be just as tough, if not tougher, taking over an existing system or service contract.

Unfortunately, stepping in to replace another technical support company can be a double-edged sword. Although gaining a new client, especially one with multiple users, can be a bit of a coup, there's always a reason as to why they want you to take over.

Sometimes it's as simple as the last serviceman retiring and the only thing the new guy has to worry about is filling the departing bloke's shoes. Many businesses form long-standing relationships with their IT provider and it can be a tense experience for a new serviceman taking on an unfamiliar office network.

Another reason people change their IT guy is that the relationship has broken down, or perhaps they haven't met expectations. It can be hard work building a rapport with any new group of people, let alone those who may be wary of a new serviceman poking around.

It may also be that the blame didn't necessarily lie entirely with the ditched service provider. I've experienced several situations where the office boss or manager had unrealistic expectations of what the serviceman's role is, how he or she goes about it and how much that service should cost. So it's quite important to have those boundaries well and truly thrashed-out before taking on any new role.

A nose for trouble

It's unfortunate but as any serviceman knows (or eventually learns), we can't please everybody all of the time, no matter how good we are at our job or how hard we try. I've knocked back several potentially lucrative jobs and service contracts over the years because the conversations I've had with the prospective clients indicated the likelihood of trouble. And while turning down any business opportunity goes against the grain, especially given the current state of this industry, sometimes we have to follow our instincts and in those cases, it meant me saying "no".

Recently, I received a call from the owner of a medical practice who was given my name by another medical professional I've done work for over the years. This chap was feeling increasingly unhappy with his current IT provider and was looking to make some changes. I told him straight away that, due to my company's situation, I was probably not the right man for the job but after chatting to him on the phone, we seemed to hit it off and the more I learnt about his plight, the more familiar it sounded.

When resetting up his practice after the quakes, he'd asked around, sourced a few quotes and pursued various options for developing his IT infrastructure. He eventually went with a company well known for their slick sales presentations, involving highly-animated salesmen who use lots of business buzz words and semi-technical patter to sell their wares. Long story short, the practice ended up with a very complicated server and multi-user workstation package with all the bells and whistles you could possibly think of bolted onto it.

Of course, none of it came cheap; not only did it cost a small fortune up-front but there was also a complicated 4-year service contract with similarly high prices for times when things went wrong.

On paper, this system looks very impressive and ticks all the IT requirement boxes. To those unfamiliar with such technology, this office set-up seemed to be a perfect solution for

Items Covered This Month

- Sorting out an office computer system
- Studio monitor distortion problem (and a door lock problem)
- Toshiba Satellite A660 laptop computer

*Dave Thompson runs PC Anytime in Christchurch, NZ.
Website: www.pcanytime.co.nz
Email: dave@pcanytime.co.nz

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in Silicon Chip? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

Studio monitor distortion problem

Many years ago, A. H. of Evatt, ACT tackled a mysterious audio distortion problem in a studio monitor at a local radio station. He ended up fixing the electric door lock to the studio as well. Here's what happened . . .

It was the practice of the AM broadcast station where I worked as a technician to use our B studio on Mondays. This was to allow maintenance work to be carried out on the main on-air A studio.

Eventually though, the announcers began complaining that the audio monitoring in B studio sounded crook! The problem was, each time it was checked, it sounded OK to the technicians. And then a chance remark by one of the announcers gave us a clue. If you turned up the monitor to absolute maximum, the sound was really distorted.

By contrast, this problem wasn't at all evident in the C studio which used the same model STC mixing console, a valve-based unit using EF86s, etc. So what was different?

That's when I became involved. During a shift handover, the day technician briefed me as to what he had done to try to solve the fault and asked if I would have a go at it during the night shift, when things quietened down. Not doubting my fellow technician, I nevertheless went through the basic fault finding procedure on the console if only to thoroughly acquaint myself with the problem and to make sure nothing had been missed.

First, I placed a record (yes one of those round black vinyl things) on the turntable and gradually increased the volume. As I did so, the audio became very distorted, so the complaints were well justified.

The problem was where to start looking. Audio from a record is all very well for subjective testing but a constant 1kHz sinewave tone would be better for troubleshooting. It was time to drag out our audio signal generator and hook it up to one of the inputs to the console.

This gave the same result as before and the higher the output, the worse the distortion.

Connecting a scope to the output of the console showed that the sinewave was clean at all levels. However, checking the output of the valve monitoring amplifier revealed that as the output neared maximum, the 1kHz sinewave turned into a 1kHz square-wave!

I quickly swapped in the monitoring amplifier from C studio but much to my surprise, the fault was still there. That meant that the only things left in audio chain were the output cabling and the monitor speaker box. As a result, I dug out a spare (smaller) speaker box and connected it directly to the monitoring amplifier, bypassing the existing cabling and speaker. That eliminated the fault, with no appreciable distortion evident even at high output levels.

So what exactly was wrong? I did not believe that the monitoring speaker was faulty. It was a 16-inch speaker rated at 100W and the monitoring amplifiers had an output of just 50W, ie, well within the capacity of the speaker.

I then ran a temporary cable from the amplifier across the floor directly to the monitor speaker and again this proved successful, with no appreciable distortion at high levels. So that left only the speaker cabling to check.

Unfortunately, it was now necessary to crawl under the desk, to access the old-style PMG soldered pin strips. Juggling a lead light in one hand, I soon discovered that a cotton-covered cable with a small tag on it saying "front door lock" was connected to the same pair of pins as the monitor speaker line.

When I removed this "lock cable", the fault disappeared and the system behaved normally. Conversely, temporarily reconnecting the lock cable reinstated the fault condition, with the 1kHz sinewave input again turning into a 1kHz square wave. Obviously, the impedance of the lock coil severely affected the monitoring amplifier.

As a result of fixing this distortion fault, an irritating long-term problem with the electric door was also cured. Its unreliability had been another long-term mystery. Indeed, on a number of occasions, the night-time announcer had come across unauthorised persons, usually drunk, in the studio after hours.

It's not hard to picture the scenario. It's a cold winter's night in Canberra, and someone who's had too much to drink has just been chucked out of a local pub. And they need to light a fag and it's windy, so they lean against the door in the alcove and as they do, the door opens. Why? – because the announcer in studio B has the monitor full on and there's just enough energy to release the door lock.

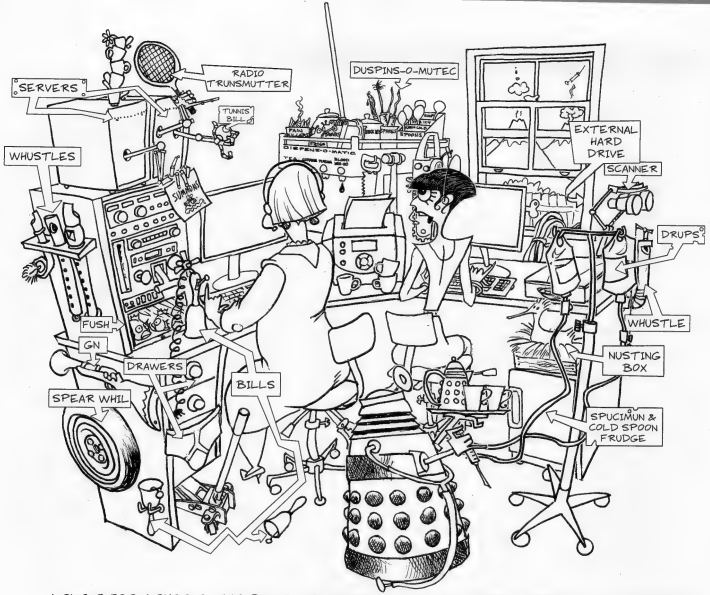
When did these incidents happen? Only when studio B was being used on a Monday! So I not only fixed the audio distortion problem but fixed the door lock problem as well. Talk about killing two birds with one stone.

anyone with a dozen or so users on a busy small-business network. My prospective client was certainly up with technology to a certain degree but like many others in similar positions, he had no real knowledge of exactly what his system involved, where all the relevant hardware was located and how it all worked together.

For example, he knew he was paying a significant monthly fee to have off-site backups done via a radio network system but had no idea what that entailed, where his data was being backed up to or what would happen in case of disaster.

Another example was the presence of an external hard drive plugged into a USB port on his server cabinet; nobody knew what it was there for or how to access it. Nor were they prepared to unplug it lest the whole system fall apart.

Of course, many clients in situations like this don't want to know what all that cabling and complicated-looking hardware is for and don't really care



LONG STORY SHORT, THE PRACTICE ENDED UP WITH A VERY COMPLICATED SERVER & WORK STATION WITH ALL BELLS & WHISTLES YOU COULD THINK OF BOLTED ON

either, as long as it all works. For many businesses, off-the-rack solutions work just fine but this often relies on people in the office changing the way they do things in order to conform to their new IT system rather than the IT system being designed specifically for the business.

On the other hand, when I look at implementing any type of office network, I look at the business and talk to the people who are going to be using it in order to determine how they do things and what their needs are. By doing this, I can understand exactly what they want and can then design a suitable system for them.

At the same time, if I see something I think could help the client better achieve what they want to do, I'll suggest all the different options available to them. That way, they can make a more educated and informed decision as to which way they want to go. What's more, by talking about things this way with the client, they usually gain a basic understanding of their office computer set-up and what it actually does.

Brick wall

To be fair, this particular prospective client had used his system for a couple of years without too many IT hiccups. What was really stirring things up now was that he needed to provide his network specifications to a software developer who was "cutting" some new code for the practice.

In particular, he was looking at changing the software the practice used for making appointments and managing patient data and the software developer wanted to know what hardware and software he was already running. However, he was hitting brick walls when he attempted to get this information from his current IT provider.

After making several unsuccessful attempts to get this information, it transpired that the people who originally installed the system were no longer with the server company and the records they'd left behind detailing the set-up were incomplete and inadequate. The bottom line was that they couldn't tell my client anything about his system other than what they could glean by remotely accessing it and having a look around. So the situation was obviously less than ideal as far as my client was concerned.

At first, the IT company tried to blame the client, claiming that the practice would have been given all the relevant material when the system

BACKUP & SPAM

was installed and if they didn't have it, they must have chucked it out or lost it. My client, who keeps every piece of paper that crosses his desk, was equally adamant he hadn't received anything like that.

As it stood, every time anyone in the office needed something like recovering a forgotten password or adding or changing a user account, they had to call the IT company. The relevant information would then be given to them or one of the company's technicians would "remote in" to the system to do the job – all for a fee.

Even the BIOS configuration in the server and each workstation computer was password protected, ostensibly to stop people "fiddling" with it. In practice of course, it also meant another expensive phone-call to IT support was required if anything needed to be done at that level. This type of IT business model is widely used in the industry and it can certainly stop employees who don't really know what they're doing (but think they do) from fiddling. However, it can be an expensive way of doing things and certainly explains why those guys drive new cars while I drive an old Mini!

In the end, by way of a compromise, the IT company offered to send a technician out to map the entire system and provide a report, although this would be done at the client's cost. By this time though, my client was not prepared to entertain the idea, hence his phone call to me.

First reactions

Based on experience, my first reaction was to walk away for what I considered two very good reasons, the first one being that I don't like walking into messes like this. If I took this job on, I'd not only have to deal with the client's expectations but also with the former (and possibly disgruntled) IT provider to get any details of the system I couldn't unravel on my own – not an ideal situation.

Second, and more significant for me, I'm now back to running things here alone. As a result, I no longer have the luxury of being able to drop everything and leave the workshop to sort out emergency on-site problems. While I could always just shut the door and go, people turn up to my workshop at all hours of the day to drop machines off or pick them up. If they arrive and find the workshop closed with a note on the door, I risk losing that client.

After all, I know how I feel if I make the effort to visit a business that advertises being open certain hours only to find it closed. I don't want my own clients feeling like that.

I talked about this to my prospective client and made it clear that I was happy to do a one-off mission. I could go after-hours to map out his system and then sit down with him and explain what everything did and how it all worked. However, my current situation meant that I would be unable to be his "go to" guy for emergency call-outs or on-site work.

After chatting to him though, it quickly became apparent that he was a very reasonable man. And so, after some persuasion, I suggested we play it by ear and see if we could perhaps work something out for after-hours scheduled maintenance of his system.

All mapped out

A week or so later, I'd mapped his system and provided him with a network map and a clear explanation of what everything did. That external USB hard drive sticking out the side of the server cabinet was placed there to provide extra disk space because the server's two mirrored hard disks were full. Not only was this a very dodgy way of adding disk space, it also didn't allow for any type of disaster recovery.

As a result, I advised getting two new and much larger hard drives for the server. Not only would that improve the performance but his valuable data would be much safer should anything happen.

The back-up system employed was also interesting. This system entailed using synchronising software on the server to update files in real time to a remote data storage facility via a radio network system. I'm still in the dark as to where this data was going but I'm pretty sure it wasn't doing what everybody thought it should be doing. That's because the database for one of the programs used by the practice is more than 160GB in size and as this changes every time appointments are added or patient records updated, it would be constantly trying to synchronise via the radio system.

As anyone who has tried to move large amounts of data via an RF link will know, it isn't the fastest method of doing things, so it was doubtful that the remote copy of the file was ever up to date with the local version.

No wonder their bandwidth bills were huge!

Back-up & spam

The first thing I did was implement a new back-up system using external hard drives that one of the staff could perform at day's end. While not ideal due to the large data files, the new software that's to be installed in a few months time will have much smaller data files, so the back-up system can easily be modified to suit when the time comes.

An interesting development was that on the very day my client sent a termination of service letter to the old IT provider, he found he could no longer send email. I hadn't been officially tasked with their office support yet but with no one else to turn to, muggins was it.

A quick check determined nobody in the office could send email either, though incoming mail was unaffected. I used remote access to pipe into their network and found their email system was working as it should, except there were 7000 plus emails queued to go out and these were unlikely to be normal office email correspondence. Opening a few at random, I could see they were identical phishing emails; someone was using the outgoing email server to send spam!

Now when this type of system is set up and configured, the person setting it up needs to be very careful to avoid just such a situation. By default, the

system must be locked down to allow only authenticated users to access the outgoing email server. Leaving it wide open is asking for trouble.

It turned out that the internet service provider (ISP) had disabled port 25 (the port that outgoing email uses) due to the sudden huge volume of email traffic emanating from this server. They had done this without notification (quite possibly automatically), which is why we had no idea it was happening.

It was easy enough to clear the email queue but as soon as I cleared it, I could see messages piling up again. A quick check of the server logs showed hundreds of failed attempts to log in to the server starting earlier that day, all with usernames beginning with A, then B and so on.

This indicated some kind of "dictionary" style username and password attack, which uses a barrage of typical user names (such as Administrator) and typical passwords (password, pass123, p4ssw0rd etc,) in an attempt to log in. It turned out that some of the existing passwords were insecure and this attack had struck it lucky, enabling access to my client's email server.

The first thing I did was enforce system-wide password changes with ultra-secure passwords (including numbers, letters and symbols such as $, #, !, +, etc). To be sure, I also prevented the Administrator account from being able to send email (this account was the one that had been compromised and has no reason to send email anyway).

I also deleted half a dozen user accounts for staff that no longer worked for the practice. That done, I checked our server and with no rogue messages in the queue, put through a request to the ISP to re-open port 25.

Since then, I have kept a close watch on things and there have been no further issues. I'd made no configuration changes while mapping the system out, so it was obviously a coincidence that the system just happened to be compromised when it was.

In the meantime, my new client is pleased that the system has been sorted out and the cost of running it substantially trimmed. We'll probably now come to some arrangement so that I can continue looking after it for him.

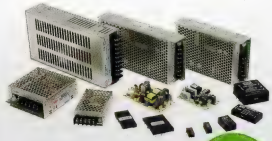
Toshiba Satellite A660 laptop

A. P. of Toowoomba, Qld recently resurrected a Toshiba Satellite A660 laptop. Here's how he solved the white screen of death . . .

Mac called me to say that the screen of his Toshiba Satellite A660 laptop was all white and he had been quoted a ridiculous amount just to have the problem looked at. My fee was more to his liking and on further questioning, it transpired that the webcam and microphone on his laptop were also not working. Furthermore, the screen had not failed suddenly – instead, it had gone through a period of intermittent operation during which it was flashing white before becoming permanently white.

The VGA output of the laptop was still working fine though, so he had been getting by with an external monitor. However, there was a further problem whereby the computer would sometimes freeze if it started up with the external monitor plugged in. Conversely, plugging the monitor in after the computer had booted always worked and so I suspected that this was probably due a driver problem and totally unrelated to the other faults.

From the information Mac provided, I suspected that the LCD panel itself



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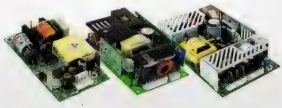

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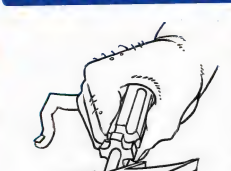
Serviceman's Log – *continued*



was actually fine and that the fault was most likely a loose connector. In this particular Toshiba model, the LVDS (Low Voltage Differential Signalling) cable that connects the LCD panel to the motherboard has a spur to the webcam. If the connector on the motherboard end of the cable had eased out of its socket over time, this would explain the problem with both the webcam and the screen.

Replacement cables

So a loose connector was one possibility but I also wanted to be prepared in case the LVDS cable itself was faulty. Replacement LVDS cables are readily available on eBay for about $25, so I promptly ordered one.

When the replacement cable arrived I collected the laptop from the client and set to work on it. Powering it up showed the display fault; the screen was pure white except for the brief moments during start-up when the display format is changed and the operating system or the BIOS turns the screen off. I then plugged an external monitor into the VGA port and was greeted by the Windows desktop.

Dismantling the laptop was slow but uneventful, most of the time being spent coaxing apart the plastic clips around the edge of the display bezel and around the keyboard bezel using the corner of a discarded SIM card. Fortunately, all the internal machine screws are identical which means they can all go into the same tray. This also later simplifies reassembly.

Once I had removed the "Logic Upper Assembly", which contains the keyboard, trackpad and speakers, I could see that the plug on the LVDS cable was still firmly lodged in its socket on the motherboard. Indeed, there was an adhesive tab holding it in place. This did not bode well for my hypothesis that the LCD panel was not at fault.

When I finally managed to get the bezel off the screen, I could see that the LVDS cable plug that connected to the webcam/microphone board had come completely out of its socket. However, since the webcam/microphone board is right next to the top edge of the display, it was quite possible that the plug had actually come out during my prying to remove the bezel.

My next step was to re-seat the three plugs on the original LVDS cable in their appropriate sockets and fire up the laptop to see if that had fixed anything. I did this without the battery or "Logic Upper Assembly" in place, so I had to plug in the charger and a USB mouse and keyboard. I also plugged in an external monitor.

The machine powered up without complaint and the display came up on the external monitor but the internal screen was still white. I wasn't out of the woods yet.

The only software on the machine I could find to exercise the webcam was Skype. I opened it up and logged in and was then able to go to "Video Settings" which showed that the webcam was indeed working again. The microphone now worked as well.

Wrong cable

The next step was to replace the LVDS cable. However, when I unpacked the new cable, I discovered that I had been sent the wrong one. The one I had been supplied had an extra plug at the motherboard end and the spur to the webcam board was too short.

Nevertheless, the motherboard and LCD panel plugs on the replacement cable were the correct kind. I figured that it might at least be electrically compatible with the original one and

so it would be useful for determining if the original LVDS cable was faulty. However, when I fitted it, the laptop just showed a white screen again.

Wrong LCD panel

That was enough evidence for me to go ahead and order a replacement LCD panel. Unfortunately, when it arrived, I found I had been sent the wrong model!

The replacement panel was not marked with any text or icons at all but its LVDS connector was in a different position than the connector on the original panel. In fact, its location was so different that the LVDS cable couldn't reach between the connector on the panel and the webcam board.

This was frustrating but once again I decided to use the incorrectly-supplied part to help me narrow down the fault. The LVDS connector on the replacement panel was most likely compatible with the original, so I plugged the panel into the original LVDS cable and turned the laptop on. And voila! – the display was now perfect, confirming that the problem had been in the panel after all.

Although the original LVDS cable still worked, the adhesive tab that held the plug into the socket on the LCD panel had now lost its "stickiness". As a result, I decided that it would be wise to also replace the cable, so I returned both the incorrectly-supplied LCD panel and the incorrect LVDS cable for a refund and ordered the correct replacements.

When these parts arrived, I lost no time in fitting them. To my considerable frustration, the display came up white again! I couldn't believe it, so I re-seated the connectors and tried again but the display was still white!

That took the wind right out of my sails! Now I didn't know whether the second replacement LCD panel or the second replacement LVDS cable was faulty, so I swapped the original LVDS cable back into the unit. And that finally fixed the problem, resulting in a stable display.

I couldn't believe that the second new LVDS cable could be faulty but that seemed to be the case. I subsequently returned it to the supplier who tested it and found that it was working but generously refunded the price anyway. Why it refused to work with Mac's laptop is anyone's guess.

As mentioned, the adhesive on the tab on the connector of the original LVDS cable had lost its "stickiness". This problem was solved by using some adhesive tape to hold it in place, after which the laptop was reassembled.

The final task was to fix the problem of the laptop freezing occasionally when it was started up with an external monitor already connected. I had told Mac that I wouldn't spend more than an hour on this part of the job and that success was not guaranteed.

I visited the Toshiba website and located the drivers for the laptop. The media manager was the most likely suspect – it was well out of date, so I upgraded it. I also upgraded the display driver and a couple of other unrelated drivers.

No more freezing

Following these upgrades, I restarted the laptop five times with the external monitor attached and it didn't freeze once. And although "absence of evidence is not evidence of absence", the allocated time had run out and it was time to return the laptop to its owner and collect my well-earned payment. SC

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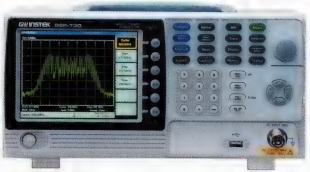

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Using the SiDRADIO to receive DRM30 broadcasts

By JIM ROWE

Guess what! Here's yet another use for DVB-T dongle-based SDRs like our SiDRADIO project: receiving DRM30 digital radio broadcasts. All you need is the SiDRADIO with your PC running an application like SDR#, plus some additional decoding software which can be downloaded from the internet.

ELSEWHERE IN this issue, we have an article on the technology of DRM digital radio. This second article shows how to use our SiDRADIO project (also in this issue) to receive and decode DRM broadcasts. It can also be used with the SDR (software defined radio) using a DVB-T dongle described in the May 2013 issue of SILICON CHIP along with the LF-HF Up-Converter described in the June 2013 issue.

If you have already been using your SiDRADIO-based SDR to receive AM or SSB signals on the MF or HF bands, using an app like SDR#, you'll be happy to hear that you can use exactly the same set-up for DRM30 reception – just by installing some more freely-downloadable software.

That sounds pretty straightforward but it isn't quite that easy, unfortunately. Although the additional software you're going to need for DRM30 reception can be downloaded freely via the internet, installing it in your PC (and configuring it) can be a bit tricky.

In fact, it's at least as tricky as installing the original RTL-SDR driver and software components for SDR reception – if not more so. And some of the additional software is not well supported by clearly-written installation and/or operating information, either.

Never fear though because this article shows how it can be done. I have spent a fair bit of time and effort (AKA trial and error) finding out how to install and use the DRM reception software successfully and now I have figured out the best way to do it . . .

The basic idea

To begin, take a look at the flow diagrams shown in Fig.1. The upper diagram (A) shows the flow of data in an SDR set-up using a DVB-T dongle-based front end like our SiDRADIO, hooked up to a PC running the RTL-SDR USB driver and an application like SDR#. This is exactly the same set-up we presented in the 'Getting Into SDR' article in the May 2013 issue, apart from the SiDRADIO box replacing the original daisy chain of an active HF antenna driving an up-converter driving the DVB-T dongle.

In this basic configuration, the digital output stream from SDR# is passed directly to the PC's sound card or on-board DACs, and then via internal or external amplifiers to the speakers.

Now look at Fig.1(B), which shows the extended configuration needed for DRM30 reception. As you can see, it's exactly the same as (A) right up to the output from SDR#. Instead of being passed straight to the sound card DACs as before, the digital output stream from SDR# is now fed to the input of the DRM decoding application DREAM, via another piece of software labelled 'Virtual Audio Cable'.

It's the decoded output from the DREAM app which is then passed to the sound card DACs and used to drive

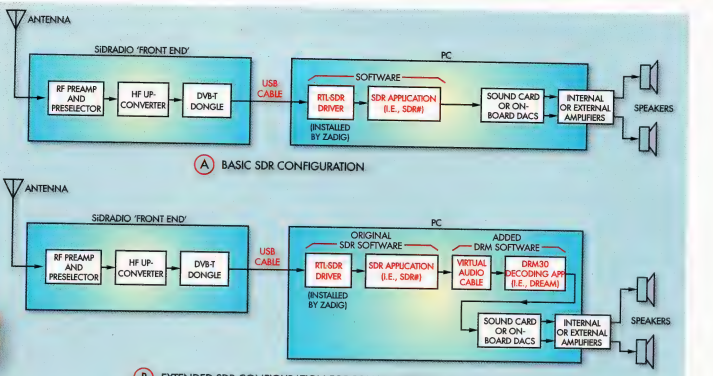


Fig.1: this diagram shows the basic SDR configuration at (A) and the revised configuration for DRM30 reception at (B). The hardware remains the same but you have to add Virtual Audio Cable & DREAM decoding software.

the speakers. In fact, the only difference between the two configurations is that for DRM30 reception, we need to install those two further software components: Virtual Audio Cable and DREAM.

Virtual Audio Cable is actually a Windows "miniport" driver written to conform to Microsoft's Windows Driver Model (WDM). It performs the function of setting up one or more 'virtual cable' ports, which allow one Windows software application to send a digital audio stream to another application – rather than to a real port like the inputs of the sound card DACs or a USB port connected to the input of external 'USB speakers'.

So you can think of Virtual Audio Cable (or VAC) as simply a driver utility, which we use to pass the digital audio data stream from SDR# directly through to the input of the DREAM application, instead of to the sound card DACs as before.

By the way, VAC was written by Russian programmer Eugene Muzychenko some years ago and has been updated and upgraded by him many times. His latest version is V4.13, which was released in July 2013. A trial version of VAC can be freely downloaded either from his website or from other download sites such as CNET – more about installing this software shortly.

Before we actually get going with the software downloading and installation, I want to warn you that because of space limitations, we won't go through the steps involved in downloading and installing the basic SDR software shown in Fig.1(A). These software installation steps were all explained in considerable detail in the May 2013 issue of SILICON CHIP, so if you haven't done this as yet you'll need to refer to that earlier article.

In the present article, we're going to assume that you have already installed the basic software for SDR and just want to extend your SDR set-up for receiving DRM30 as well.

The new software

The first additional software component you'll need is Virtual Audio

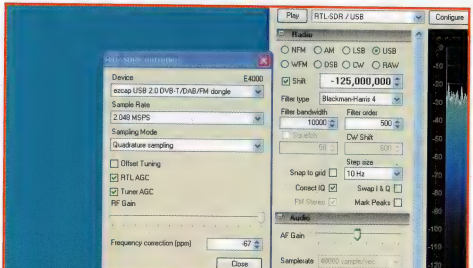


Fig.2: once Virtual Audio Cable is installed, it should appear in the Audio section of SDR# (listed here as [MME] Virtual Cable 1).

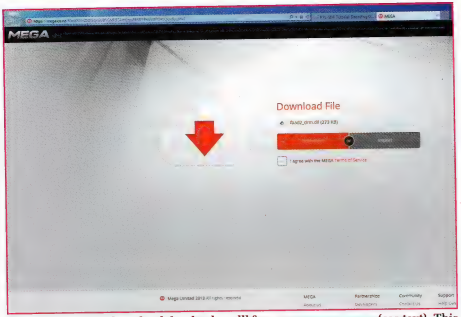


Fig.3: you need to download *faad2_drm.dll* from www.mega.co.nz (see text). This dll file must then be copied to the folder where you installed DREAM.

Cable. As mentioned above, a trial version of VAC can be downloaded at no cost from either Mr Muzychenko's website or from the CNET website (see the Useful Links panel) but be warned that this version has the irritating property of injecting a female voice saying "trial version" into the digital audio stream from time to time.

This can disrupt DRM decoding, so I suggest you purchase and download the fully-functional version online from his website. It costs between A$26.50 and A$52.70, depending on the level of online support you choose. For most people the Basic Support version is probably quite sufficient and this costs A$36.85.

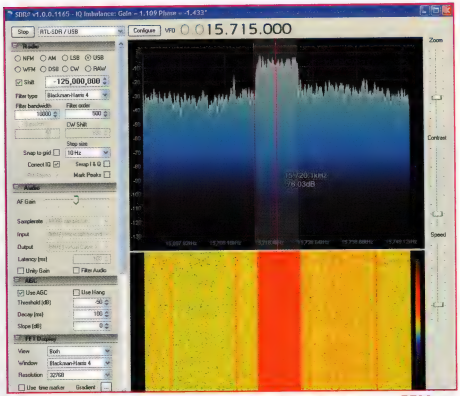


Fig.4: the waterfall display in SDR# when the software is set to tune a DRM30 signal from NZKI centred on 15.720MHz. SDR#'s displayed frequency is 15.715MHz (ie 5kHz below the centre frequency), as shown by the large digits just above the spectrum display window (see text for explanation).

VAC4.13 downloads as a compressed zip file. To install it on the machine you're using for SDR and DRM30 reception, unzip the download file into an empty folder on this machine (**C:\Program Files\VAC** is a good choice) and then double-click on the *setup.exe* file. It's then just a matter of following the instructions.

Note that because VAC4.13 is basically a driver rather than an application, you won't see any icon for it on your desktop after it has been installed. Instead, you will see a 'Virtual Audio Cable' folder in the 'All Programs' list and if you select this you'll see a number of items including a Control Panel icon.

This allows you to do all kinds of highly technical set-up adjustments but you really don't need to worry about this if you're just going to use VAC as a single virtual audio cable between SDR# and DREAM. It automatically sets itself up as 'Virtual Audio Cable 1' during the installation.

If you want to confirm that it has done this, just go into Start -> Control Panel -> Hardware and Sound -> Device Manager -> Sound, Video and Game Controllers, and you should see 'Virtual Audio Cable 1' listed.

Next, it's a good idea to plug the USB cable from SiDRADIO into the USB port you're using for it and then fire up SDR#. Make sure that you have set-up SDR# to work with the RTL-SDR/USB device and that it's set initially for AM reception. Then click on the Play button at upper left. You should find that when you tune into an AM signal, you'll hear its audio coming from the PC speakers as usual.

Now click on the Stop button at upper left and look down SDR#'s left-hand control panel until you find the Audio control area. Here you'll find the Output label, with a text box to its right showing your current audio controller. When you click on the down arrow at the righthand end of this text box, you should see another option with a name like 'Virtual Cable 1' or '[MME] Virtual Cable 1' – see Fig.2.

Click on Play again and you'll see SDR# begin scanning once again. There will be no sound coming from the PC's speakers because the audio output from SDR# will now be going into VAC's virtual audio cable. So the silence shows that VAC has been installed correctly and is ready to do its job.

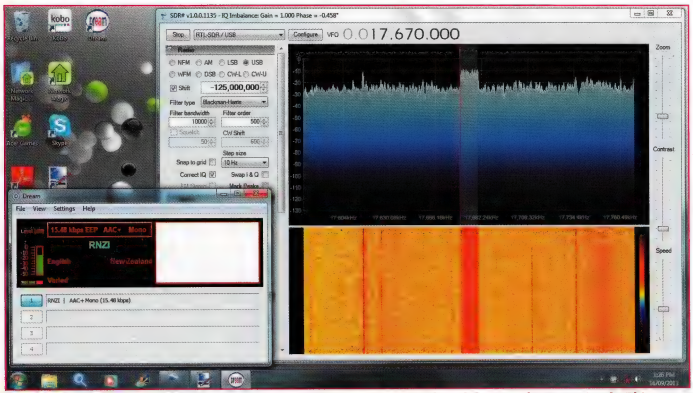


Fig.5: you'll need to fire up SDR# before running the DREAM application to demodulate tuned DRM30 signals. This screen grab shows the two applications running on a Windows 7 desktop.

Just before you move on to install DREAM, click on SDR#'s Stop button and then change its audio output back to the usual 'sound card' setting for SDR reception. This makes it easier to search for DRM30 signals, after DREAM has been installed. Also click on the USB radio button in the Radio area at the top of SDR#'s lefthand control panel, so that it becomes SDR#'s demodulation mode (you can see the button with a green dot in Fig.2).

Next, move down to the text box just under the label 'Filter bandwidth' (in about the centre of the Radio area), click in this text box and type in 10000, as shown in Fig.2 as well.

You will now have set up SDR# for DRM30 reception, apart from switching its audio output over to VAC and DREAM once you have found and tuned in a DRM30 signal. That will be easy to do later, so for the present just close down SDR# by clicking on its red Exit button at top right.

Getting & installing DREAM

Now you can download and install DREAM, the second item of software needed for DRM30 reception. Doing this is more complicated because for copyright reasons, one component of DREAM cannot be included in or with it before downloading. It must be downloaded separately from a different website and then added to the same folder as the rest of DREAM.

This 'secret' component is **faad2_drm.dll**, which as the name suggests is an application extension. It's a very important one in fact, because it's the MPEG-4 HE-AAC v2 codec which DREAM needs to decode DRM signals.

The first step is to download the rest of DREAM, from the **www.sourceforge.net** URL shown in the Useful Links panel. You'll find the latest version of it there as a zip file, with a name like **Dream-1.17-qt4.zip** and a file size of about 12.8MB (ie, that's the name and size of the latest version at the time of writing).

Download the zip file and unzip it into a suitable folder on the same PC you're using for SDR#. I suggest you create a folder with the name like **C:\Program Files\Dream**, for example. You'll probably need administrator privileges to do this, especially with Windows 7.

Once all of the files have been unzipped into this folder, you'll find the DREAM app itself in the folder as **Dream.exe**. You might want to create a shortcut icon on your desktop, with this exe file as its target. You'll then be able to launch DREAM at any time, simply by clicking on the shortcut.

Before you do this, you need to download that all-important **faad2_drm.dll** file containing the HE-AAC2 v2 codec in pre-compiled form. In order to download this file you'll need to go to the URL shown in the Useful Links box – the one at the website **www.mega.co.nz** with the weird and wonderful 53-character codeword.

If you go directly to this website you'll need to type this full codeword into your browser very carefully (with no spaces) or it won't work and you won't be able to download the file.

There is another way to get to it though, if you find it just too hard to type it in successfully. That's to go to the fourth URL given in the first section of our Useful Links box – the one at **www.rtl-sdr.com**, leading to a tutorial on using an rtl-sdr to receive DRM.

If you open this tutorial (which has a lot of useful information, by the way), you'll find on about the third page a paragraph of text about the **faad2_drm.dll**, and towards the end of this paragraph there's a link called 'this megaupload link'. If you click on this link, it'll take you directly to the correct download page of the **www.mega.co.nz** website, as shown in Fig.3.

You should then be able to download the **faad2_drm.dll** file just by clicking on the large red down arrow in the centre.

Once you have downloaded the **faad2_drm.dll** file, it's simply a mat-

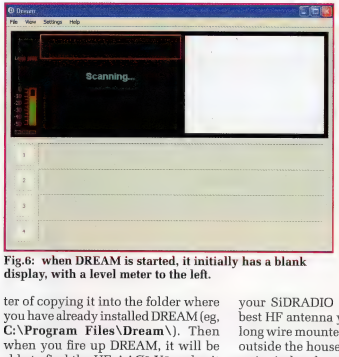


Fig.6: when DREAM is started, it initially has a blank display, with a level meter to the left.

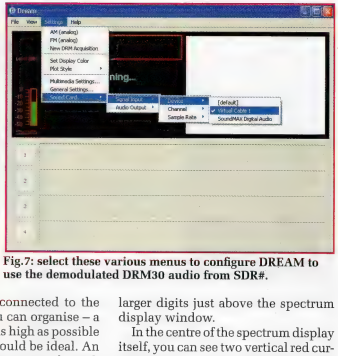


Fig.7: select these various menus to configure DREAM to use the demodulated DRM30 audio from SDR#.

ter of copying it into the folder where you have already installed DREAM (eg, **C:\Program Files\Dream**). Then when you fire up DREAM, it will be able to find the HE-AAC2 V2 codec it needs for decoding DRM30 signals.

So that's the procedure for acquiring and installing the additional software needed for using your SDR set-up to receive DRM30 signals. Now we can discuss what's involved in using it with the SiDRADIO.

Receiving a DRM30 signal

To paraphrase an old saying, the first step in receiving a DRM30 signal is to find one. And as noted in our general article about DRM elsewhere in this issue, DRM signals are not that easy to find at present in our region of the world.

You should refer to the table shown in Fig.4 of that article and use it to guide you in searching for one of the signals at the frequency and broadcasting time shown in the table. Here are a few tips to make things easier:

(1) Make sure that the LF-HF input of your SiDRADIO is connected to the best HF antenna you can organise – a long wire mounted as high as possible outside the house would be ideal. An active indoor loop antenna *might* work but then again it might not.

(2) Initially, you should use SDR# with its Audio output switched to the PC's sound card, with its demodulation mode set to USB (upper sideband) and its Filter bandwidth to 10kHz, as noted earlier.

(3) When you are looking for a known DRM30 signal, set the receiving frequency of SDR# to a figure 5kHz lower than the listed frequency for that signal. That's because the listed frequency is the centre frequency of the DRM30 signal block but in upper sideband mode we have to set SDR#'s 'local oscillator' to the bottom of the signal block – which is in most cases 10kHz wide.

This is shown the screen grab of Fig.4, where SDR# is set to receive a DRM30 signal from NZRI centred on 15.720MHz. SDR#'s receiving frequency is 15.715MHz, as shown by the larger digits just above the spectrum display window.

In the centre of the spectrum display itself, you can see two vertical red cursor lines – one at the lefthand end of the DRM30 signal block corresponding to SDR#'s tuning frequency and the other in the centre of the block where I had positioned the mouse cursor to show the centre frequency just before capturing the screen grab.

(4) When you have managed to find a DRM30 signal like that shown in Fig.4, use the tuning and RF gain controls of the SiDRADIO to achieve the best possible signal level – using both the spectrum analyser and waterfall displays of SDR# to guide you. The idea is to set SiDRADIO's RF gain to about 60% and then carefully adjust its in-band tuning control until you see the noise+signal level rising as high as possible on the spectrum display.

(5) Next, turn up the RF gain control until the 10kHz-wide band on the waterfall plot becomes as dense as possible, showing that the DRM30 signal is at the highest possible strength. You should end up with a display rather like that in Fig.4.

At this stage, you will only be hearing a hissing sound from the speakers because the audio output from SDR# is still going 'that-away'. So now you have found a DRM30 signal, stop SDR# temporarily while you redirect its audio output to Virtual Audio Cable 1.

To do this, click on the down arrow at the end of the Output text box in SDR#'s Audio area and select '[MME] Virtual Cable 1' (as shown in Fig.2). Then click SDR#'s Play button to restart it again. You will now be hearing nothing, since DREAM is not running as yet.

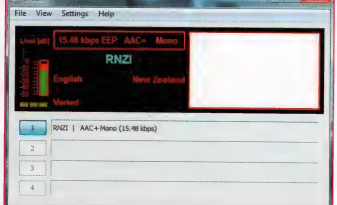


Fig.8: this screen grab shows a typical display in DREAM when a DRM30 signal in tuned. In this case, the station is RNZI and DREAM indicates that the signal has a sampling rate of 15.48kps and was encoded in mono using the AAC+ codec. The signal strength is also shown.

Next, fire up DREAM. Note that SDR# must be running before you do this and it must also be running all the time you are using DREAM, because DREAM needs SDR# to provide its demodulated DRM30 signals for decoding.

You will also need SDR#'s displays to guide you in making any adjustments that may be needed to optimise DRM30 reception. So you'll find it best to have both applications visible on your desktop, arranged as shown in Fig.5. As you can see, the SDR# display is at upper right on the screen, while DREAM's smaller display is at lower left.

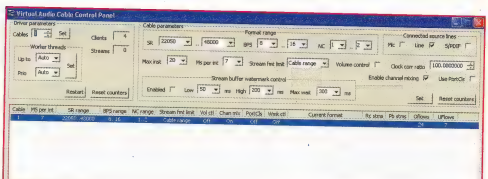


Fig.9: the virtual audio cable driver (VAC) must be set to transfer digital audio samples at up to the same rate as SDR#, ie, 48kS/s. That's done by starting VAC's control panel app and checking that the figures for the 'SR range' (given in the summary line for Cable 1) are '22050..48000'.

Driving DREAM

When you start DREAM, you'll see a largely blank display like that shown in Fig.6, with a small level meter bar chart at centre left and a single message 'Scanning . . .' in blue in the centre of the black quadrant at upper left.

You then need to configure DREAM to take its input signal from the VAC virtual cable, ie, use the demodulated DRM30 audio coming from SDR#. Click on the Settings menu head to get the drop-down menu shown in Fig.7, then click on the Sound Card listing at the bottom of this menu to get a flyout sub-menu offering a choice of options: Signal Input or Audio Output.

Clicking on Signal Input will produce another flyout menu with three options: Device, Channel and Sample Rate. Click on Device to see a further flyout menu allowing you to choose between [default], Virtual Cable 1 or the name of your PC's sound card.

At this point, your DREAM display should be as in Fig.7, with the above chain of menus. The sound card of the PC concerned is at the bottom of the final flyout list, called 'SoundMAX Digital Audio'. However, the centre item here is Virtual Cable 1, which is highlighted and ticked to show that it has been selected as the input device.

This is the main step in setting up DREAM, although if you wish you can click on the Sample Rate item in the second-last flyout, to check that DREAM is set for an input sampling rate of 48kS/s. If not, select that rate.

You can also go back to the first flyout and select Audio Output, to check that DREAM is also set up correctly to feed its own decoded digital audio out to your PC's sound card DACs. If that's also true, you have now set up DREAM correctly so that it's ready to roll.

The small level meter display at lower left in the black quadrant of DREAM's display should be displaying a green bar at least halfway up. If it's not up this far, go back to SDR#'s display dialog and move the Audio Volume slider to the right a little, until the meter in DREAM does show a green bar extending up this far.

Now if the DRM30 signal you've tuned to is strong enough, DREAM should whirr away for a few seconds and then announce that it has recognised a DRM30 signal. Its display should look like Fig.8, where the things to note are the information in the black quadrant showing that it has found an RNZI signal from New Zealand with a program in English, encoded using the AAC+ codec (AKA HE-AAC V2), in mono and with a data rate of 15.48kbps.

This information is also shown more briefly in the top row of the lower half of DREAM's display, labelled as '1'. The other three rows are blank because the DRM30 signal concerned only had one service at the time.

Note also that green bar of the level meter at lower left of the black quadrant is about 3/4 of the way up, showing that the strength of the DRM30 signal being received is fine. Finally, note the row of three green bars just below the level meter. These show that the received signal quality is also quite good (although varying a bit, as revealed by the word 'Varied' in red alongside).

You should also be hearing the decoded DRM30 audio via your PC's speakers. This will be the final confirmation that your DRM30 reception set-up is working correctly.

Troubleshooting

But what if you were unable to get this far, for some reason? Here are some troubleshooting tips:

You need to make sure that SDR# is set for sampling at 48kS/s. You can

Useful Links

(1) For more information about DRM and decoding it via RTL-SDR:
www.drm.org/wp-content/uploads/2013/09/DRM-guide-artwork-9-2013-1.pdf
en.wikipedia.org/wiki/Digital_Radio_Mondiale
en.wikipedia.org/wiki/High-Efficiency_Advanced_Audio_Coding
www.rtl-sdr.com/tutorial-drm-radio-using-rtl-sdr/
sourceforge.net/apps/mediawiki/drm/index.php?title=RTL2832U_Guidance

(2) Websites for downloading Virtual Audio Cable (VAC):
software.muzychenko.net/vac.htm
download.cnet.com/Virtual_Audio_Cable

(3) Website for downloading DREAM, the DRM Receiver application:
sourceforge.net/projects/drm/files/dream/

(4) Website for downloading precompiled faad2_drm.dll:
https://mega.co.nz/#!m5RUHIDQ!SqcGUBSGMFSTAm09XX78RDYRoIJW0T545QQRJ_dFuE

What About Direct Sampling?

A few readers have contacted us since we described the HF Up-Converter for DVB-T dongles in the June 2013 issue, asking us about an alternative 'direct sampling' approach to achieving LF-HF reception. Details of this approach have appeared on a number of websites, with a particularly informative one to be found using this URL: **www.rtl-sdr.com/rtl-sdr-direct-sampling-mode/**

Basically, the direct sampling approach involves surgery on the PCB inside the dongle – see Fig.12:

(1) Break one of the two differential digital signal paths linking the outputs of the E4000/FC0013/R820T tuner IC and the inputs of the RTL2832U COFDM demodulator IC.

(2) Connect an HF antenna to either one or both of the freed differential inputs of the RTL2832U, either directly or via a suitable HF balun. This allows the RTL2832U to sample the HF signals from the antenna directly, without needing an up-converter to shift them up into the VHF tuning range of the tuner IC.

Apart from the need to perform quite delicate surgery on the very small PCB of most DVB-T dongles, this approach is relatively straightforward. That's because the developers of SDR# made provision for it to accept direct sampling from either the 'I branch' or the 'Q branch' inputs of the RTL2832U chip, instead of the usual 'quadrature sampling' mode used when the tuner IC is still in use.

Note: if you open SDR#'s Configure dialog for the RTL-SDR/USB dongle in use and click on the down arrow at the end of the text box below the Sampling

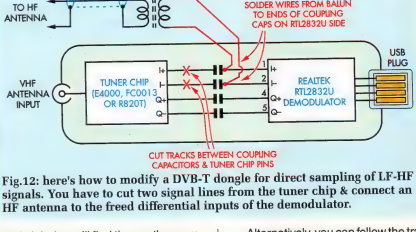


Fig.12: here's how to modify a DVB-T dongle for direct sampling of LF-HF signals. You have to cut two signal lines from the tuner chip & connect an HF antenna to the freed differential inputs of the demodulator.

Mode label, you'll find these other sampling options.

So if you don't mind the challenge of microsurgery on a tiny DVB-T dongle PCB, this direct sampling approach might be worth a try. Here's how to do it:

The differential inputs of the RTL2832U chip use pins 1 & 2 (for the I+ and I- inputs) and pins 4 & 5 (for the Q+ and Q- inputs). In most DVB-T dongles, these pins are connected to the I+, I-, Q+ and Q- output pins of the tuner chip, via tiny SMD coupling capacitors.

The easiest way to break one of these two differential links is to cut the tracks on the PCB between one pair of these coupling capacitors and the outputs of the tuner chip. For example, you can follow the tracks from pins 1 & 2 of the RTL2832U chip (the I+ and I- inputs) to find the coupling capacitors for the 'I' channel, and then carefully cut the tracks leading from these capacitors back to the tuner chip outputs.

Alternatively, you can follow the tracks from pins 4 & 5 of the RTL2832U chip (the Q+ and Q- inputs) to find the 'Q' channel coupling capacitors and then cut the tracks leading from these capacitors back to the tuner chip outputs.

This isn't as easy as it might sound but it turns out to be easier and safer than trying to remove one pair of capacitors from the PCB – because trying to remove them usually results in lifting their solder pads as well, together with some of the tracks leading to them.

It's also difficult trying to solder wires directly to pins 1 & 2 (or 4 & 5) of the RTL2832U. The pins on this chip are very closely spaced, making bridging between them almost inevitable.

So our suggestion is to cut the tracks between the coupling capacitors and the tuner chip, but leave the coupling capacitors in place because it's easier to solder wires to the RTL2832U ends of the capacitors than to try soldering

check this simply by looking closely at the Sample Rate text box in the Audio area of SDR#'s lefthand control panel, where you should be able to see **48000 sample/sec** displayed in light grey.

If not, stop SDR# and exit from it, and then use a text editor application like Notepad to open the file **SDRSharp.exe.Config**, which you'll find in the **C:\Program Files\SDR#** folder on your hard disk (or whichever folder you've used to install SDR#).

If you look down through this file, you'll see a series of lines starting with **<add key=** , followed by a text string in quotes and then a parameter value.

Find the line which starts like this:

<add key="minOutputSampleRate"

This line should continue and end like this:

value="48000" />

If it doesn't, edit the line so that it looks exactly like this:

<add key="minOutputSampleRate" value="48000" />

Make sure you copy this line exactly, noting where the spaces are and where there are no spaces. Also make sure the line begins with the '<' character and ends with the '/>' combination and save the file again, Now when you start up SDR#, it should display **48000 sample/sec** in its Audio Sample Rate text box.

You also need to make sure that the virtual audio cable driver (VAC) is set for transferring digital audio samples at up to the same rate of 48kS/s. You can do this by starting up VAC's control panel app and checking that the figures for the 'SR range' given in the summary line for Cable 1 (in the lower dialog box – see Fig.9) are '22050..48000'.

If the maximum figure is not 48000, you can change it by typing this number into the second text box in the top row of the 'Cable parameters' area at upper right.

If you're sure that SDR#, VAC and DREAM can communicate at the sam-

them to the pins of the chip itself.

Luckily, even if you damage the PCB trying to make this mod to the 'I channel' (pins 1 & 2) inputs of the RTL2832U chip, all is not lost because you can try again with the 'Q channel' inputs (pins 4 & 5). And SDR# is just as happy doing direct sampling via the Q channel/branch as it is doing it via the I channel/branch.

But is this direct sampling approach worth doing? To find out, I modified one of our dongles and tried it out. The results were quite good for AM reception on the LF and MF bands, with the antenna coupled into the RTL2832U chip directly via a small balun.

I then tried using the front end of the SiDRADIO to provide some RF gain and preselection ahead of the RTL2832U and checked this hybrid approach on the shortwave bands. The results were not too bad up to about 9MHz but there were all kinds of 'birdies' and other interference when tuning to higher frequencies.

My impression was that there was quite a bit of cross-modulation from the 28.8MHz clock oscillator in the dongle, causing some of these problems.

So overall, I can recommend the direct sampling approach if you just want to use a spare DVB-T dongle for SDR reception of the local AM radio signals. But for more serious reception on the shortwave bands, our Up-Converter or SiDRADIO would be far superior.

And don't forget that once you've operated on a dongle to try out the direct sampling approach, it would probably be almost impossible to convert it back for VHF-UHF reception using the tuner chip.

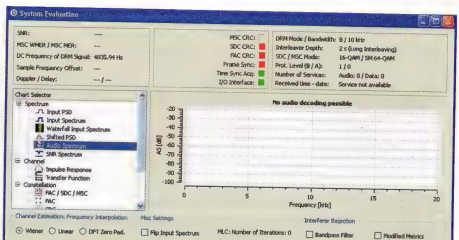


Fig.10: if the System Evaluation dialog displays 'No audio decoding' possible, then signal strength & quality is the likely problem (ie, the signal strength is inadequate for reliable decoding).

Fig.11: the System Evaluation dialog can also display the decoded constellation diagrams for the received DRM30 signal's FAC, SDC and MSC data channels.

pling rate of 48kHz, yet you still don't seem to be able to receive a DRM30 signal properly, the most likely cause is that you are not able to receive DRM30 signals at a high enough level to allow reliable decoding.

If this is what is happening, look carefully at the upper black quadrant of DREAM's display – and in particular at the signal level meter and the three rectangular 'LEDs' just below it. You'll probably see the green signal level bar only extending up by less than half the range and one or more of the three signal quality indicators either dark or red – indicating that DREAM simply doesn't have enough to work on.

To explore this further, click on the View menu heading at the top of DREAM's display dialog and then click on the 'Evaluation Dialog . . .' line in the drop-down menu. This will cause a System Evaluation dialog to be displayed, like the one shown in Fig.10. If the white window on the right is virtually empty and has the legend 'No audio decoding possible', then signal strength and quality is almost certainly your problem.

You can also click on the FAC/SDC/MSC line in the Constellation section of the Chart Selector list at centre left of the System Evaluation dialog. You'll then see DREAM's display of the decoded constellation diagrams for the received DRM30 signal's FAC, SDC and MSC data channels, plus a lot of other data as shown in Fig.11.

Above the constellation diagram, you'll see a vertical column of six display 'LEDs', each with its own label. Basically, you won't achieve good decoding of a DRM30 signal unless all six of these indicators are GREEN. Even if the lowest five indicators are green and only the top indicator labelled 'MSC CRC:' is red (as shown in Fig.11), you still won't get good decoding and reception. SC

Highly accurate, low cost alcohol analysis . . .

ALcOLYSER

You've probably seen a few breath alcohol monitors in the past but this one is quite different – this simple system measures the amount of alcohol in the drink before it ever reaches your mouth (or stomach (or kidneys, or whatever!). It determines the percentage of alcohol in any drink with two very important parameters: high accuracy and low cost. Compare it with commercial units costing tens of thousands of dollars!

by Allan Linton-Smith

The components of Al's Alcolyser: a Digitech Fuel Cell Alcohol Tester with supplied mouthpieces (Jaycar QM7302), a heated Travel Mug (Jaycar GH1301), an accurate thermometer (or a thermocouple and DMM), a caulking gun nozzle and some lengths of plastic tube. The 12V power supply at left is for the Travel Mug, while the Digitech electronic scale at rear (Jaycar QM7264) is for accurately weighing the alcoholic drink sample and water.

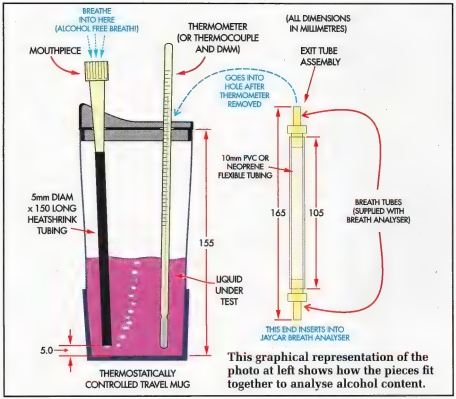
ABOUT THAT NAME:
Well, it is an alcohol analyser designed by Al . . . so what else would you call it?

Not only is it easy to build, it works with all drinks (many analysers only work with specific drinks) and it also works over a very wide range – from no alcohol at all (0%) right through to nearly pure alcohol (95%).

And it can even be used to calibrate one of those cheapie breath alcohol analysers as well, so you can be pretty much assured that when that is telling you you're still under the limit, you ARE under the limit.

One word of warning: if you do happen to earn the attention of the boys in blue, don't try to use this as evidence in a court, because it won't impress the magistrate one little bit. As they say in all good disclaimers, it's for educational and/or entertainment purposes only and no responsibility for its use or consequences of its use will be accepted by the management . . .

Having said that, if you're accurate with your samples and temperature, the accuracy of this simple system will be right up there with the big boys!



This graphical representation of the photo at left shows how the pieces fit together to analyse alcohol content.

Introduction

This unit uses fuel cell technology (see panel) to evaluate the alcohol content of drinks. Not only is it accurate but it is $0000's cheaper than most alternatives.

You might think there's a zero or two too many there but that's the amount of money you'd need to spend on a commercial equivalent (and then spend a fortune to keep it calibrated).

Not only will it assist makers and consumers of wines, spirits, liqueurs, mixers, RTDs (ready-to-drink beverages) and cocktails, it may be used by those seeking to identify alcohol in beverages when it is not wanted!

For example, we tested a "lemon, lime & bitters" (a commonly-ordered "non alcoholic" drink), bought over a bar, and this indicated that it contained over 1% alcohol (from the Angostura bitters, which contain 44.7% alcohol!).

Our system is quick, easy and requires minimal training. Part of it uses a commonly available fuel-cell meter and a temperature-controlled travel mug (which heats the sample to the required temperature) while the rest is easy to build, requiring only a drill and a few pieces from your local hardware store!

How do you measure alcohol?

If you've ever dabbled with making home brew, we can hear you saying "that's easy, just use an alcohol hydrometer." But it's not quite that simple.

Those instruments are perfectly good for beer and even wine and pure spirits. But what if you have to measure drinks which are a mixture of alcohol & sugars or juices – such as "mixers" (eg, a bourbon and cola), RTDs, ports, liqueurs and cocktails?

Or what if you want to check the teenagers' (theoretically non-alcoholic!) fruit punch that might have some – ahem – surreptitiously added "extras"? A hydrometer simply won't work at all!!

The problem is that sugars add to the density of a drink. A hydrometer used for beer and wine works on densities lower than water but sugars in drinks are greater than water.

Once you have **any** significant amount of sugar in an alcoholic beverage, your hydrometer becomes basically useless.

The measurement of alcohol content is often a problem for makers of fortified wines such as port, sherry, RTDs and liqueurs or any alcohol which contains sugars.

Microdistillation

One of the methods used for determining alcohol content relies on micro distillation, where a predetermined test sample is put into a still and the condensed alcohol is weighed. This has to be done by trained personnel and is expensive!

One of our contacts in the liquor industry recently paid $14,000 for an automated instrument of this type!

Other techniques such as infrared spectroscopy are also very expensive, typically $25,000 and they have a limited range – you need at least two of these instruments to cover 0-20% and 20-60% alcohol, whereas ours covers 0-95% alcohol.

Those instruments are extremely accurate, down to 0.02% and if calibrated correctly will stand up in court. They are highly recommended if you have $50,000 to spare!

But if you want something 300 times cheaper you may want to consider our setup which is typically accurate to ±0.5% – maybe not accurate enough for a court of law but more than accurate enough for most users.

How it happened

Necessity being the mother of invention, we wanted to help a friend who makes wines and other beverages so he could quickly check the alcohol in his liqueur, which contained a lot of sugar.

He wanted to know how many "standard drinks" was in a bottle. (We

Here's a close-up of the heart of the system, the Digitech (Jaycar) QM7302 Breath Analyser. The opaque circular piece at the top is actually the breath tube into which you blow to get a reading of blood alcohol content (%BAC). We're using it in a different manner than the manufacturer intended!

make no comment about his readiness to allow us to sample his wares. . .)

Accurate breath analysers, incorporating fuel cells are readily and fairly cheaply available. We thought we might try the one offered by Jaycar (QM7302 @ $119.00) to see if we could determine the alcohol content of various beverages.

We reasoned that if you bubbled some (sober) breath through a warm test sample (body temperature) and measured the outcome, you would be able to calculate the alcohol content.

Providing you knew the concentration of that sample you would be able to convert the reading to the percentage of alcohol by volume (ABV).

It worked well – in fact, much better than we expected... so here it is!

How it works

This project uses the fuel cell alcohol tester combined with the Jaycar GH-1301 thermostatically controlled travel mug (to accurately set the temperature), connected by a short tube.

The operation is very simple: a 1-4g sample of an unknown alcoholic beverage is made up to 200ml with water and is placed in the travel mug, which is set to reach a temperature of 39-40°C

Once the sample solution reaches 40°C you blow into the mouthpiece, bubbling air through the liquid and then read the blood alcohol content (%BAC) from the fuel cell breathalyser.

By referring to a conversion chart you will be able to convert a %BAC reading to %ABV (alcohol by volume) for your test sample.

Naturally the dilution of the test sample has to be in the range of the breath tester which is specified at 0.00-0.4%.

So you will have to make a weaker solution for strong alcoholic drinks (1g/200ml) and stronger solutions for weak drinks (4g/200ml) and then just read off the chart for that particular concentration.

We took quite a few measurements using the Jaycar unit with various alcoholic solutions to establish the conversion chart and were happy that it was accurate and more importantly, the results were repeatable.

Some losses will occur mainly in the exit tube where there may be some condensation. Most of it will be water but a tiny amount of alcohol is lost (distillers call this the "angels' share").

We could heat the tube to prevent condensation but we feel this is not necessary and will complicate the project.

Those of you who wish to use the device in the tropics need not worry too much but may find problems if you live in Antarctica or high on Everest's slopes!

Keeping the exit tube short helps considerably and we have set up the chart using a standardised length of tube because a longer tube will incur higher losses.

It is easier to take measurements with a longer exit tube but the results will be unreliable.

Parts List – Alcolyser

1 fuel cell alcohol breath tester (eg, Jaycar QM7302)
1 heated travel mug (eg, Jaycar GH-1301)
1 105mm length of 10mm PVC or Neoprene tubing
1 *unused* caulking gun nozzle
1 150mm x 5mm diameter heatshrink tubing
1 laboratory (mercury) thermometer (or thermocouple and DVM)
1 accurate digital scale (eg, Jaycar QM-7264)
1 12V 3A power supply (with lead and RCA plug to connect to travel mug) or use a 12V car battery with the lighter plug lead which is included with the travel mug.

Other applications

You can also use the setup to check and/or calibrate other breath testers. Many of these are not accurate or they have changed with age, abuse (or simply don't work at all!).

If you are using a personal breath tester, we urge you not to rely on it before you drive, unless you have had it checked. Better still just don't drink and drive at all!

Even wall-mounted units in pubs and clubs can be way off unless they are frequently calibrated according to the manufacturers' instructions. (Once again, that's why they have those disclaimers!).

We checked a $10 unit and at 0.05% it gave a reading of 0.04%, and at 0.06%, a 0.0% result – so don't trust them!

Calibration for these devices is usually done by putting a standardised alcohol solution, usually 0.38% ABV (alcohol by volume), in a calibrating vessel at 38-40°C.

Then the operator blows into it bubbling air into this standardised mixture which feeds to the breathalyser via a short tube.

You can check the 0.05% level by weighing 2.5g scotch plus 197.5g water.

We have to hope that the operator is not too drunk otherwise the machine will be set incorrectly and will always read too low! In fact, this applies just as much to our system – any alcohol in the operator's breath will obviously skew the results.

So beware – there is no guarantee that any breath analyser, large or small is correct. Unless, of course, it is one in one of those vans with flashing red and blue lights – these are regularly calibrated and are declared (by law) to be scientific instruments which means you can't argue with their results.

To calibrate another breathalyser you can compare a reading from the Jaycar unit to the breathalyser under test.

You should try different concentrations of alcohol because one reading is really not enough to verify that it is working.

Some breath analysers do not have provision to fit a tube and you only need blow over the top of it for a few seconds. To check these you will only need to aim the exit tube to the receptor and keep it very close.

This method is also used by various Police departments to check their hand held breathalysers and they use rather expensive devices to do this!

As an aside, this device would have been very handy a couple of decades ago when a certain teenager (who must remain nameless, Craig) developed a taste for his father's Jim Beam. Said father never did work out why said JB tasted so "weak" until many years later, son admitted to father that he used to refill the bottle behind the bar with water to mask his nefarious activities.

So if you think your drinks are being "watered down" at your pub or club, here's the way to accurately check them!

Construction

Cut a piece of tubing to the specified length of 105mm and fit a plastic mouthpiece (supplied with the Fuel Cell Alcohol Tester) to each end. Two mouthpieces are provided with each breath tester and you can purchase extra ones separately if needed.

Drill two 7mm holes in the lid of the mug as per the diagram and seal the slider with some insulation tape. One of these holes does double duty – it's used for both a thermometer (or thermocouple) and (when at the right temperature) for the outlet tube.

Many thermometers and thermocouples will also fit through the outlet tube anyway, so if yours does the outlet tube can be left *in situ*.

Then fit 165mm of 5mm diameter heatshrink tubing over the end of the caulking gun nozzle and push it into one of the holes.

Push your thermometer (or thermocouple) into the other hole.

You are now ready to calibrate and test!

Operating and calibrating

We have made things pretty easy by doing all the calculations and conversions for you but we do recommend a check to ensure the breath tester is working correctly.

Firstly warm it up by blowing directly into it to check if the tester reads zero.

Obviously, you need to be absolutely stone cold sober for this, otherwise you will have to wait until you zero it. And if you remember that your body only "loses" 0.015% of blood alcohol per hour, that could be a rather long wait!

Breath Analysis: the players

There are three major types of breath alcohol testing devices, each based on different principles. Regardless of the type, each device has a mouthpiece, a tube through which the person blows air and a sample chamber where the air goes to be analysed.

Older style **"Breathalyzer"#** – Uses a chemical reaction involving alcohol that produces a colour change

Intoxilyzer – Detects alcohol by infrared (IR) spectroscopy

Alcohol Sensor – Detects a chemical reaction of alcohol in a fuel cell

Breathalyzer

The Breathalyzer device contains:

- A system to sample breath
- Two glass vials containing the chemical reaction mixture
- A system of photocells connected to a meter to measure the color change associated with the chemical reaction

The breath sample is bubbled in one vial through a mixture of sulphuric acid, potassium dichromate, silver nitrate and water. Sulphuric acid removes the alcohol from the air into a liquid solution and the alcohol reacts with potassium dichromate to produce chromium sulphate, potassium sulfate, acetic acid and water. The silver nitrate is a catalyst which makes accelerates the reaction without participating in it. During this reaction, the reddish-orange dichromate ion changes color to the green chromium ion when it reacts with the alcohol; the degree of the color change is directly related to the level of alcohol in the expelled air. To determine the amount of alcohol in that air, the reacted mixture is compared to a vial of unreacted mixture in the photocell system, which produces a voltage proportional to the colour change which is calibrated for alcohol concentration.

Intoxilyzer

This device uses infrared (IR) spectroscopy and identifies molecules based on the way they absorb infrared light.

The various bonds within molecule absorb IR at different wavelengths. In ethanol the bonds (C-O, O-H, C-H, C-C) absorb the IR light at different wavelengths and these wavelengths help to identify the substance as ethanol and the amount of IR absorption tells you how much ethanol is present.

A lamp generates a broadband (multiple-wavelength) IR beam, which passes through the sample chamber and is focused by a lens onto a spinning filter wheel which contains narrow band filters specific for the wavelengths of the bonds in ethanol. The light passing through each filter is detected by the photocell, where it is converted to an electrical pulse and then is relayed to a microprocessor which calculates the BAC based on the absorption of this filtered infrared light.

In general, the larger table-top units found in Police stations and in some "booze bus" installations are IR spectroscopy types.

FUEL cell type

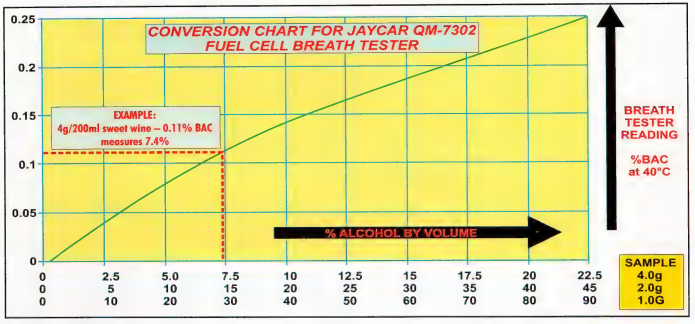
Modern fuel-cell technology (the same as which may power our cars and even our houses some day) has been applied to breath-alcohol detectors. Devices like the one in our project use this technology.

The fuel cell has two platinum electrodes with a porous electrolyte material sandwiched between them. As the exhaled air from the breath flows past one side of the fuel cell, the platinum catalyses the oxidation of any alcohol in the air to produce acetic acid and in the process moves electrons across the electrolyte.

A voltage is generated between the two electrodes proportional to the amount of alcohol and this is measured and converted to BAC by a microprocessor.

The protons move through the lower portion of the fuel cell and combine with oxygen and the electrons on the other side to form water.

 # "Breathalyzer" is the registered brand name and trademark of a particular manufacturer (specifically Dragerwerk AG, a German conglomerate). However, like many words in our language, it has become synonymous with a wide range of breath analysis devices. We are using the name in this context.



Then connect the breath tester to the exit pipe making sure that all connections are secure.

If you have a balance or electronic scale which is accurate to 0.1g, weigh out exactly 1.0 gram of scotch whiskey (blended scotch is always 40% ABV; you may also use vodka or brandy as long as the strength is 40%) and make this up to 200g with water. Ideally, that would be pure or distilled water but in most circumstances, ordinary tap water will be satisfactory.

Note that "normal" kitchen scales will not be good enough unless they are accurate to one gram. To maintain sample accuracy with one gram scales you should multiply everything by ten (eg, 10g/2litres).

The Jaycar QM7264 digital scales we used have a resolution of 0.01g.

Place the alcohol/water mixture in the travel mug and hook it up to a power source (12V/3A) or to the 12V cigarette lighter socket in your car and set the temperature to 40°C (104°F).

When the sample has reached 40°C on your separate thermometer you can pull the plug out because the mug may exceed the dialled in temperature. Conversely, if it doesn't reach 40°C you may need to set it to a higher temperature.

You may wish to leave the mug in its default mode which shows °F, in which case you can do all your measurements at 100°F

Every time you remove power to the mug, all settings will be lost.

(Every mug will be different so you may need to set it a bit higher if it won't go to 40°C.)

The mug we used is fairly well insulated so it will maintain the temperature for a few minutes, enough to do two or three repeats. For accuracy, you must check the temperature of the sample between tests with a separate thermometer such as a digital thermometer or glass thermometer because the mug is only designed to heat coffee – it is not super accurate.

Bear in mind that if it is too hot or too cold your readings will be incorrect.

Follow the instructions provided with the QM7302 alcohol tester and warm it up as recommended.

When everything is ready and the tester beeps for you to "blow" hold down the button and blow gently and steadily into the mug for six seconds or until you hear a second beep. Don't blow too hard or you may risk blowing big droplets into the tester.

If all is well, you should get a reading close to 0.20%.

Jaycar's specifications indicate that the accuracy of this tester is ±0.008%.

Our measurements of alcohol were typically accurate to ±0.5%, which is almost good enough for establishing a wine alcohol label!

The conversion chart shows how to calculate the %ABV of a beverage from a %BAC reading on the Jaycar unit for 1, 2 or 4 gram samples in 200g water.

Note that we have specified grams of water here instead of the usual "ml" because you are weighing the sample on the scale, not measuring it by volume. Of course, 200ml of pure water will weigh 200g.

Do's and don'ts

- DO read all the instructions which accompany the tester and the mug.
- DON'T switch on the mug without liquid
- DO remember temperature is important, so keep the sample as close to 40°C as is possible
- DO give the breath tester time to recover after four samplings
- DO dry the mug and tubes before adding the sample
- DO accurately weigh the sample and water – weigh 1g (or 2g or 4g) then add water to 200g – ie, 1g sample +199g water
- DO measure the sample immediately – if it sits too long alcohol will evaporate.

Examples

Example 1: a 4.0 gram test sample of sweet white wine, labelled 8.0%, gave an average reading of 0.11% so tracing down we will get a measurement of 7.8% ABV. (yellow line)

Example 2: a 1.0 gram sample of an unknown spirit gave a reading of 0.215% and again tracing down we get 70% ABV – quite a strong spirit!!

If you have no idea what the approximate alcohol content is then do a rough reading using 1g and then increase it to 2g or 4g to get higher readings (and hence more accuracy) on the breath tester.

You may need to do a few practice runs to be sure, to be sure! SC

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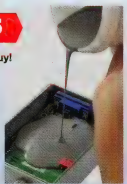

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SiDRADIO: an integrated SDR using a DVB-T dongle

. . . incorporating a tuned RF preselector/amplifier, an up-converter & coverage from "DC to daylight"

Last month, we introduced our SiDRADIO communications receiver and described the circuit and PCB assembly. This month, we show you how to make and fit the various metal shields and complete the construction by installing it all in a plastic instrument case.

Pt.2: By JIM ROWE

AS STATED last month, the PCB assembly and its companion DVB-T dongle are housed together in a low-profile ABS instrument case. Since the case itself provides virtually no EMI shielding (apart from new front and rear panels which are made from double-sided PCB laminate), the fairly high sensitivity of the front-end circuitry means that extra shielding must be added to achieve an acceptable level of performance.

In fact, three separate shields are necessary: (1) a small vertical shield in the front centre of the PCB (see Fig.6 in Pt.1 and the internal photos), (2) a lower horizontal shield and (3) an upper horizontal shield.

Fig.10 shows the details for the small vertical shield. It's made from 0.8mm-thick sheet aluminium or tinplate which is first cut to size and then bent up in a small bench vise.

A 3.5mm hole near the front of the mounting flange allows this end to be secured under the PCB's front-centre mounting screw, while a second hole (at the rear) lines up with a matching hole near the centre of the PCB.

Once this shield has been made, secure it to the PCB via its rear mounting hole using an M3 x 9mm machine screw, lockwasher and nut (feed the screw up from underneath the PCB). This not only secures the shield in place but also ensures that it is connected to the PCB's earth copper.

Fig.11 shows the dimensions and cutting details of the lower horizontal shield but note that this diagram is drawn half size (50%) for space reasons. This shield is cut from 0.25mm copper foil or tinplate and requires a small semicircular cut-out near its front centre, to provide clearance for

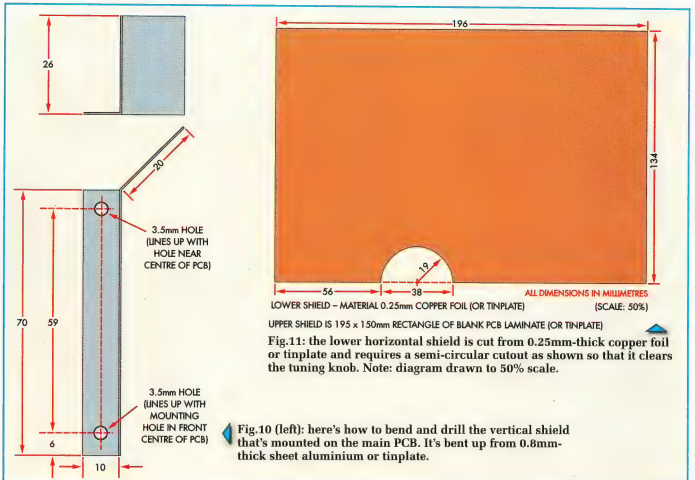

Fig.11: the lower horizontal shield is cut from 0.25mm-thick copper foil or tinplate and requires a semi-circular cutout as shown so that it clears the tuning knob. Note: diagram drawn to 50% scale.

Fig.10 (left): here's how to bend and drill the vertical shield that's mounted on the main PCB. It's bent up from 0.8mm-thick sheet aluminium or tinplate.

the tuning knob (note: PCB laminate material is too thick for the bottom shield).

When it has been cut to shape, this shield can be fitted inside the bottom of the case and secured using double-sided foam tape. Note that, depending on whether the case comes from Jaycar or Altronics, it may be necessary to cut away a number of central pillars using side-cutters or a chisel, so that they don't foul the shield.

Note also that you must leave a small area of exposed copper (or tinplate) near the lower lefthand (front) corner so that you can solder a short length of hookup wire to it. The other end of this wire is then later connected to the GND terminal pin (TPG2) in that corner of the main PCB.

The upper horizontal shield is simply a rectangle measuring 195 x 150mm and is cut from either blank PCB laminate or tinplate. This is secured inside the top of the case using double-sided foam tape. As with the bottom shield, you need to solder a short length of hook-up wire to it, this time at the left rear (ie, roughly above CON3). This wire is subsequently used to connect the top shield to the PCB earth copper via TPG3.

Front and rear panels

Although the case is supplied with ABS front and rear panels, they cannot be used here as they don't provide any shielding. Instead, these panels are replaced with custom panels made from doubled-sided PCB material. These PCB front and rear panels (code 06109132 and 06109133) are available from SILICON CHIP (see our website) and are supplied pre-drilled with red solder masking and silk-screened lettering for a professional finish (see photos).

Both panels also have a solder pad at one end (on the inside) so that they can be connected via short lengths of hook-up wire to the adjacent earth (TPG) pin on the main PCB. This, together with the added shields, ensures adequate RF shielding for the sensitive front-end circuitry.

Preparing the case

The upper half of the case needs no preparation at all, apart from fitting the upper shield as described earlier. However, as stated above, it may be necessary to cut away some central pillars on the lower half of the case.

In addition, it's necessary to remove a 30.5mm long section of the ribs on either side of the front-panel mounting slot, to provide clearance for the tuning knob. This can done using a hand-held rotary tool after first marking the section to be removed, using the front panel as a guide.

Just remove enough material from the ribs to bring them down to the same level as the inside bottom of the case.

Adjusting the rotary switch

Before fitting rotary switch S2 to the front panel, you first need to trim its shaft to about 9mm. It then needs to be converted from a 6-position switch to a 5-position switch.

That's done by first rotating the switch fully anticlockwise and removing the mounting nut and lock-washer. The indexing plate is then lifted up and replaced with its pin going into the hole between the '5' and '6' digits

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moulded into the switch body.

Check that the switch now has five positions, then fit a flat washer over the indexing plate, followed by the lock-washer. The switch can then be fitted to the front panel and secured with its mounting nut.

Once the switch is in position, cut 12 x 40mm lengths of light-duty hook-up wire (eg, from a short length of multi-colour ribbon cable). Remove about 5mm of insulation from the ends of each wire, lightly tin the bared ends and solder two of these wires to the centre (rotor) lugs on the rear of the switch. The other 10 wires should then be soldered to outer lugs 1-5 and 7-11 – see Fig.6 in Pt.1.

Note that these digits are moulded into the rear of the switch and you must solder each one to its corresponding number on the PCB (the switch diagram in Fig.6 is representative only). The rotor connection lugs are identified as 'A' and 'C' (the latter going to the "rotor B" pad on the PCB).

Final assembly

Now for the final assembly. The first step here is to mount the PAL/Belling Lee socket (CON4) on the rear panel. This must be fitted with its earth lugwasher, lock-washer and nut on the inside and orientated so that the earth lug is at the same level as the rear centre pin. The earth lug must also be to the right of the centre pin, as viewed from inside the case (see Fig.6 in Pt.1).

Next, remove the mounting nut from HF input socket CON3, leaving the lock-washer in place, then fit the rear panel over CON3. That done, refit the mounting nut but don't tighten it up fully at this stage. Adjust the panel so that CON4's centre pin rests on its rectangular connection pad on the top of the PCB just to the rear of RLY1.

The front panel can now be fitted to the main PCB assembly. First, remove VR1's mounting nut but leave the lock-washer in place, then attach the panel with VR1's shaft, LED1 and toggle switch S1 all passing through their matching holes. VC1's tuning knob should also be protruding through its clearance slot, while the body of rotary switch S2 should be just resting on the top of the PCB.

Once it's in place and lined up correctly, fit a flat washer to VR1's threaded ferrule and then refit its mounting nut to hold it all together. The completed assembly can then be lowered into the case, with the front and rear panels slipping down into the matching slots on either side.

The rear panel carries the two antenna sockets and has a cutout to provide access to the USB socket. Note the two earth leads running from TPG2 to the rear of the front panel and to the bottom horizontal shield. Note also that the mounting screw used to secure the central shield near transformer T1 is fed up from the underside of the PCB.

During this procedure, make sure that the end of the earthing wire for the lower shield is accessible, down at the front lefthand corner.

Once it's in place, check that the main board is seated properly, then fit the 10 4-gauge x 6mm self-tapping screws to secure the PCB inside the case. These screws all mate with the small mounting pillars that are moulded into the bottom of the case. Note that the screw in the front centre position on the PCB also passes through the front hole of the vertical shield plate.

The next step is to solder all the wires from the rear of rotary switch S2 to their correct terminal pins on the PCB. It's just a matter of matching the pin numbers and letters on the switch to those on the PCB.

Earthing wires

Next, solder the end of a short piece of hook-up wire to the earth pad on the back of the front panel (near S2), then solder the other end of this wire to the

adjacent PCB earth pin (TPG2). The wire from the lower shield should then also be connected to TPG2. This connects both the front panel and lower shield to the main PCB's earth copper.

Similarly, connect TPG3 to the earth pad just to the right of CON3 on the rear panel. That done, connect CON4's earth lug to its PCB pad using a short length of tinned copper wire.

The assembly can now be completed by fitting the control knobs to band switch S2 and to RF gain pot (VR1) and then plugging in the DVB-T dongle.

Fitting the DVB-T dongle

As shown in Fig.6 in Pt.1, the DVB-T dongle fits into the cut-out at the righthand end of the PCB, with its USB plug mating with CON2 at the rear. If necessary, it can be further secured using hook and loop material (eg, Velcro) attached to the underside of the dongle and to the bottom of the case.

The DVB-T dongle's RF input is connected to the PCB via a 100-120mm length of 75Ω coaxial cable fitted with a PAL/Belling Lee plug (or whatever plug is needed for your dongle) at one end. The other end is simply stripped and the centre conductor and screening braid soldered to the appropriate PCB pins.

By the way, if your dongle came with one of those el-cheapo baby whip antennas, you can make use of its antenna cable to avoid having to make up a new one. Simply cut the cable about 120mm from the dongle plug end and connect this end to the terminal pins on the PCB.

In fact, this is the best way to go if your dongle uses a small MCX connector for its RF input.

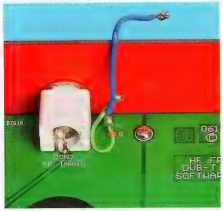
Initial checkout

Your completed SiDRADIO is now ready for initial testing. All that's necessary to do this is to move toggle switch S1 to its upper position and then connect CON1 to your PC via a standard USB cable (ie, with a USB type A plug at the PC end and a USB type B plug at the SiDRADIO end).

Provided you have already installed the RTL-SDR driver and an SDR application like SDR# (see the May 2013 article), Windows should recognise the dongle as soon as the USB cable is plugged in. Assuming that's the case, connect a suitable VHF/UHF antenna to CON4 of the SiDRADIO and fire up SDR#. You should now be able to see any VHF-UHF signals that are being picked up by the dongle in the usual way, ie, just as if the dongle were plugged directly into the PC's USB port.

If all goes well, click on SDR#'s STOP button and switch on the SiDRADIO using power switch S1. Check that LED1 turns on, then check the output from the DC-DC converter (IC2) by measuring the voltage between 'TP 12V' and 'TPG4' on the PCB (these two test points are just to the right of the vertical shield plate). You should get a reading of close to 12.5V when gain control VR1 is turned fully anticlockwise, dropping to around 12.0V when VR1 is turned fully clockwise.

You should also check the voltages at the input and output of REG1, located



Terminal pin TPG3 (to the right of CON3) is connected to the earth pad on the rear panel using insulated hook-up wire, while a second lead (shown here as the blue wire floating at one end) must be connected from TPG3 to the top horizontal shield.

just to the rear of T2. The voltage on its input pin (on the right) should be very close to 5.0V, while the output pin (on the left) should be very close to 3.3V.

If these voltages all measure OK, the SiDRADIO's front-end LF-HF circuitry is probably working correctly. If so, connect a suitable LF-HF antenna to CON3, use rotary switch S2 to select a suitable band (say Band 3, 1-3.4MHz), and set RF gain pot VR1 to mid-way. That done, click on the small box just to the left of the 'Shift' label in SDR# on your PC and set it to make allowance for the 125MHz up-conversion. Finally, click on SDR#'s 'Play' button again to resume operation.

You should now see a spectrum display of LF-HF signals and if you set SDR# to scan in that part of the spectrum centred on about 1.0MHz, you should see a number of signal peaks corresponding to various AM radio stations. Then if you select one of these peaks, you should be able to tune it for maximum signal by nudging the SiDRADIO's tuning knob one way or the other.

Note that the tuning is fairly broad and not at all critical.

Note also that if the signal you wish to tune is near the top of the band, you may need to adjust the small trimmer capacitors on VC1 to their minimum settings (ie, fully unmeshed). They're easily accessed through small holes in the top of VC1 and can be adjusted using a small screwdriver or alignment tool.

You should now find that advancing RF gain control VR1 produces an obvious effect on SDR#'s display. In fact, if you turn VR1 up to 'full bore', this may well cause the signal peaks to rise above the overload level. In most situations, you'll rarely need to turn the RF gain up that far.

Finishing up

There are no further adjustments and the operation should now be quite intuitive. **All that remains is to solder the end of the wire from the upper shield plate copper to terminal pin TPG3** on the main PCB (near CON3), after which you can fit the top half of the case into position and secure it using the four supplied screws.

You May Need To Install .NET Framwork 2.0

SOFTWARE DEFINED RADIO, May 2013: a reader has discovered that the SDR software combination (Zadig + RTL-SDR + SDR#), as described in the May 2013 article, would not run on a PC with Windows XP (SP2) but would run on another Windows XP/SP2 machine.

The solution was to install *Microsoft .NET Framework 2.0* and reboot.

Newer operating systems may come with this preinstalled. If you do need to install *Microsoft .NET Framework 2.0*, it can be downloaded from the internet. Note that this note also applies to the SiDRADIO.

You should also fit four adhesive rubber feet to the bottom of the case, so that it won't scratch any surface it's placed on.

With the unit completed, you're now free to explore the LF, MF & HF bands in the same way that you've been exploring the VHF and UHF bands. And of course, you can return to exploring the VHF and UHF bands at any time simply by switching the SiDRADIO off and clicking again on the box just to the left of SDR#'s 'Shift' label to de-activate the 125MHz frequency offset.

Finally, note that an article on using the SiDRADIO to receive DRM (Digital Radio Mondiale) broadcasts in the shortwave bands is featured elsewhere in this issue. SC

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The Assault 700 DFC is mostly pre-built requiring only a few hours for final assembly, electronics installation and setup. The bare kit (no electronics or main rotor blades) sells for $214.99

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Test Equipment Review . . .

Gratten GA4063 3GHz Spectrum & GA1484B 4GHz Signal Generat

The GA4063 Spectrum Analyser features a large colour LCD and has a basic frequency range from 9kHz to 3GHz.

If you're in the market for a spectrum analyser or a signal generator capable of working at the frequencies used by mobile phones, cordless phones, WiFi networking and so on, don't restrict your search to instruments from the USA or Europe. These two new units from Atten Instruments in China are most impressive in terms of performance, build quality and value for money.

NOT LONG AGO, it was almost a foregone conclusion that if you wanted a top-quality test instrument, you had to go to one of the 'big name' design and manufacturing firms in the USA or Europe. And when you found what you were looking for, you'd end up paying the proverbial 'arm and a leg' to buy it and get it delivered to your benchtop.

But things started to change when the big US and European firms began to get their instruments manufactured in China, to their own designs. Before long, the Chinese firms acquired a great deal of expertise from contract OEM manufacturing, allowing them to expand into designing and manufacturing their own instruments. Soon they emerged as full-scale global players in the test instrument market, with brand names competing directly with those long established in the US and Europe.

As a result, we now have an expanded range of test equipment makers to choose from, together with the benefits of stronger competition in the market, including prices held in check.

The two instruments being reviewed here are excellent examples of this. They are both from Shenzen Atten Electronics Co Ltd in Shenzen PRC, which has been producing test instru-

Analyser
or

Review by JIM ROWE

The rear panel of the GA4063 carries three ports (USB host, Ethernet LAN & RS-232C), any of which allow the unit to be operated remotely. Also on the rear panel are three BNC sockets providing a triggering input, a buffered output from an internal 10MHz reference and an input for an external 10MHz reference.

ments for some years using the brand name "Atten Instruments" but is now using the name "Gratten Technology". But enough preamble – let's take a look at the two instruments.

GA4063 Spectrum Analyser

Physically, this is the smaller of the two, housed in a compact portable case measuring 400 x 210 x 136mm (W x H x D) and weighing 7kg. It's only a little larger than many of the current portable DSOs, yet offers a surprising range of features. For example, there's a colour LCD panel with a diagonal dimension of 212mm and a display resolution of 800 x 480 pixels.

But that's only the start. The basic frequency range of the GA4063 is from 9kHz all the way up to 3GHz, with a span which can be varied between 100Hz and 3GHz with a resolution of 1Hz, as well as 0Hz (zero span). The resolution bandwidth (RBW) can be varied between 1Hz and 3MHz in 1-3-10 steps, while the video bandwidth (VBW) can be varied over the same range and with the same steps (but not necessarily locked together).

An interesting feature is that the GA4063 has triggered operation with zero-span mode. This means that it can be used like an RF oscilloscope and can capture pulse patterns in bursts such as in car key-fobs etc. In addition, for narrow-band sweeps, it can operate in FFT mode with a small resolution bandwidth. This means that intermittently occurring signals anywhere in the band are captured.

The GA4063 has an input attenuator range of 0-50dB, adjustable in 10dB steps. The maximum safe input level is +30dBm (7.07V RMS) with the input attenuator set for -20dB, for frequencies between 2MHz and 3GHz. There's also an input preamplifier, covering the range between 100kHz and 3GHz. The analyser's reference level can be set to any level between -100dBm and +30dBm, in 1dB steps (setting resolution 0.01dB).

Input VSWR (voltage standing wave ratio) is less than 1.5:1 between 10MHz and 3GHz, with 10dB or 20dB input attenuation – very good for such a wide frequency range.

The displayed average noise level (DANL) for the frequency range 10MHz-2.5GHz is -130dBm with the input preamp off, dropping to -148dBm when the preamp is turned on. For the low end (100kHz-10MHz), the corresponding DANL levels are -120dBm with the preamp off and -130dBm with it turned on. Similarly, for the high end (2.5GHz-3.0GHz), the DANL figures are -120dBm with the preamp off and -140dBm with it turned on.

Typical phase noise with 10kHz offset from a 500MHz carrier is quoted as less than -95dBc/Hz, falling to below -100dBc/Hz at an offset of 100kHz and to lower than -120dBc/Hz for an offset of 1MHz.

All of this is pretty impressive and compares very well with similar instruments from US and European makers, costing much more.

Other nice features include a very flexible graphical user interface with a choice of 'hard' function buttons, 'soft' button menus, with a keypad or a rotary control to adjust settings; the ability to set up to four measurement markers; the ability to save traces, settings or screen images to internal flash memory; a 'file manager' which allows any of these files to be copied to a flash drive plugged into the front-panel USB port and the ability to operate the GA4063 remotely via any of three ports on the rear panel – a USB host port, an Ethernet LAN port or an RS-232C serial port.

Also on the rear panel are three BNC connectors which provide a triggering input for the GA4063, a buffered output from the internal 10MHz frequency reference and an input for an external 10MHz reference.

The GA4063 is also available with an optional Tracking Generator, with its output made available at a second N-type socket on the front panel. The Tracking Generator has a frequency range from below 2MHz to 3GHz, with an output level which can be varied between 0dBm and -25dBm in 1dB steps. The output impedance is 50Ω, the same as the input impedance of the analyser itself.

Power consumption of the GA4063 is typically 24W from any 100-240V AC mains supply (50-60Hz).

The GA4063 comes with a User Manual, a Programming Manual, a power cable and a small plastic tool box containing a range of useful acces-

The GA1484 Signal Generator features a large LCD panel to display the operating parameters. Its RF output can be adjusted anywhere from 250kHz to 4.0GHz with a resolution of 0.1Hz and is set using the keypad or varied using the rotary control at top right.

sories: a number of N-type to BNC and SMA adaptors, an SMA-SMA coupler, three signal cables with SMA connectors on each end, a signal cable with BNC connectors on each end, a LAN jumper cable, a small whip antenna with SMA connector, two mains fuse cartridges and an 80mm CD-ROM with its labelling in Chinese – so I can't be sure of the contents. It may provide a driver for interfacing the GA4063 with a PC.

GA1484 Signal Generator

The signal generator is somewhat larger than the analyser, measuring around 425 x 450 x 145mm (W x D x H) and weighing around 10kg. Clearly, it's intended to be located on a benchtop, rather than lugged around for mobile testing. But like the GA4063, it offers a very impressive range of features along with performance of a high order.

For a start, there's a TFT-LCD panel measuring 178mm (seven inches) diagonally and used to display many of the operating parameters, along with the legends for the 'soft' function buttons just to the right of the display. There's a keypad and a rotary control to input frequency, output amplitude and other parameters, plus eight 'hard' function buttons which are used to select RF output frequency, output level, modulation mode and level and so on.

A further three buttons on the left select local/remote control, call up a preset configuration or ask for help (via the GUI). Three more buttons on the right control the RF Output (on/off), modulation (on/off) and the LF output (on/off).

The main RF output is via a standard N-type female connector at lower right, while the internal LF modulation oscillator's output is also made available at upper right via a BNC connector.

Before we leave the externals, there are no fewer than eight BNC sockets on the rear panel of the GA1484, with functions as follows: 10MHz internal timebase output, 10MHz external timebase input, external trigger input, sweep signal output, external pulse modulation input, internal pulse modulation output, external analog modulation input and internal trigger signal output.

Also on the rear panel are the mains power input, a USB type B host connector, an Ethernet LAN connector and a GPIB connector. The last three are for remotely controlling and programming the GA1484 from a PC or other network controller.

It's in terms of performance that the GA1484 is particularly impressive. Its RF output can be set to any figure from 250kHz right up to 4.0GHz, with a resolution of 0.1Hz and a stability of better than ±1ppm for the 'A' version, or ±0.1ppm for the 'B' version. The frequency can be set directly using the keypad or varied from the current setting using the rotary control.

The RF output level can be set to any figure between -127dBm (100nV) and +13dBm (1.0V), with a resolution of 0.01dB and an accuracy of better than ±1dB. The RF output is via an N-type socket on the front panel, with an output impedance of 50Ω and a rated VSWR of below 1.8:1. The output level can be set in a range of units: dBm, dBμV, mV, μV, mVemf or μVemf.

The rated SSB phase noise level at 20kHz offset from a 1GHz carrier is less than -105dBc/Hz for the 'A' model, and less than -115dBc/Hz for the 'B' model. The residual FM with zero modulation (CW) is less than 30Hz peak for the 'A' model and less than 10Hz peak for the 'B' model; this is for a 1GHz carrier and a bandwidth from 300Hz to 3kHz.

There are four basic modulation modes: AM, FM, phase modulation and pulse modulation. In each of these modes, the modulating signal can be sourced from either an internal LF generator or an external source via one of the rear panel connectors.

When the internal LF generator is used for AM modulation, the modulation depth can be adjusted to any level between 0% and 100%, with a

resolution of 0.1%. The modulation frequency can be adjusted to any value between 20Hz and 20kHz, with a rated distortion of less than 2% when modulating a carrier of 0dBm to a modulation depth of 80% at 1kHz.

For frequency modulation, the frequency deviation range can be adjusted between 20Hz and 100kHz, while the modulation frequency can be adjusted between 20Hz and 80kHz. Rated distortion with a modulation rate of 1kHz and a deviation of 50kHz is less than 1%.

For phase modulation, the modulation frequency can be varied between 300Hz and 20kHz. The phase offset range can be set between 0 and 10 radians with a modulation rate of below 10kHz, or between 0 and 5 radians for modulation rates between 10kHz and 20kHz. Rated distortion with a modulation rate of 1kHz and an offset of 5 radians is less than 1.5%.

For pulse modulation, the pulse width can be adjusted between 400ns and 2s, while the pulse period can be varied between 1µs and 2s. The modulation rise and fall times are rated as less than 60ns, while the carrier on/off ratio is greater than 60dB.

As well as these standard functions, the GA1484 offers another very useful facility: frequency sweeping. Here too it's very flexible, giving you the ability to set the start and stop frequencies, the output power/amplitude at both the start and end of the sweep (separately), the number of 'dwell' points between the two (2 - 100+), and the dwell time at each point (minimum 1ms).

The spacing can be set to be either linear or logarithmic. It's also possible to sweep through a list of designated frequencies, instead of a series of regularly-spaced points.

The GA1484 is supplied with a User Manual, a Programming Manual and a power cable.

Trying them out

Thanks to Gratten Technology's Australian representatives, Trio Test & Measurement, we were able to check out both instruments at the same time. As a result, we were able to use the GA4063 to check the performance of the GA1484, at least for frequencies below 3GHz, as well as using GA4063 to look at a variety of other signals – eg, from WiFi routers, 2.45GHz cordless phones and other devices.

We could also use it to check the harmonics of the 125MHz crystal

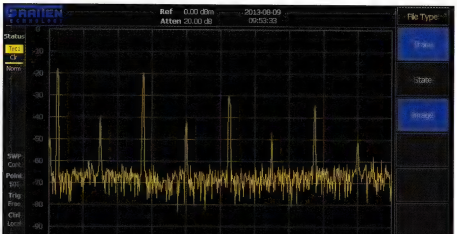


Fig.1: this screen grab from the Gratten GA4063 Spectrum Analyser shows the "raw" output spectrum from the 125MHz crystal oscillator in the 'LF-HF Up-Converter For SDRs, as published in June 2013. Note the harmonics up to 1GHz.

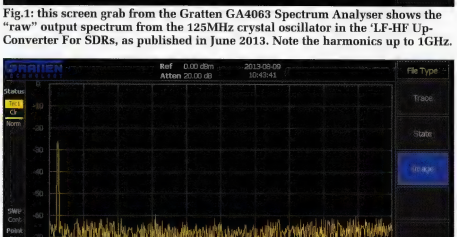


Fig.2: the same signal after filtering, before it is fed into the mixer chip. Note that all harmonics have been attenuated below the -60dBm level.

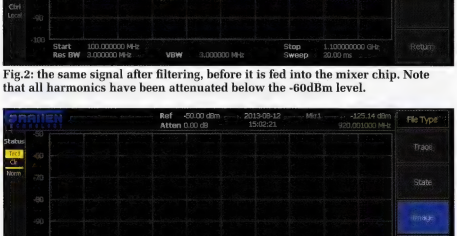
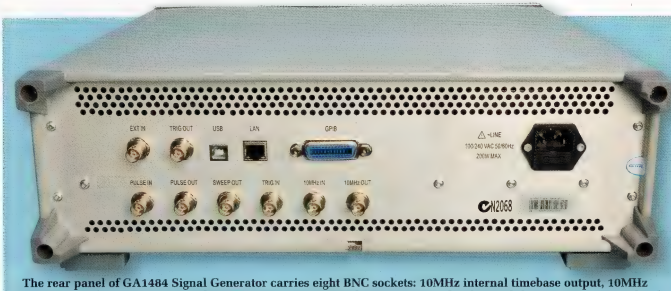


Fig.3: here the GA4063 Spectrum Analyser is showing the output from the GA1484 Signal Generator, with the latter set to 920MHz and an output level of -127dBm (= 100nV).



The rear panel of GA1484 Signal Generator carries eight BNC sockets: 10MHz internal timebase output, 10MHz external timebase input, external trigger input, sweep signal output, external pulse modulation input, internal pulse modulation output, external analog modulation input and internal trigger signal output. Also on the rear panel are a USB-type B host connector, an Ethernet LAN connector and a GPIB connector, any of which can be used for remotely controlling and programming the GA1484 from a PC or other network controller.

oscillator in our LF-HF Up-Converter for SDRs (SILICON CHIP, June 2013) and also the performance of the LC filter we used to 'clean up' the oscillator output to get better cross-modulation performance from the balanced mixer.

We were also able to use the GA4063 with its inbuilt tracking generator to measure the performance of various cables over the frequency range 9kHz-3GHz, as well as that of the UHF input amplifier stage in one of the prototypes of the SILICON CHIP 12-Digit Frequency Counter (December 2012-January 2013). In short, we gave both instruments a fairly thorough work out.

Our basic conclusion is that both instruments stack up very favourably against broadly comparable instruments from the hitherto 'big name' manufacturers, in terms of both performance and build quality; especially when you consider their significantly lower cost.

The only minor criticisms we could make with regard to both instruments is the degree of clarity in their User Manuals, which does leave a bit to be desired. A few more chapters in each manual walking you through various common measurement set-ups would certainly not go amiss.

Overall, both instruments are pretty good in terms of the English clarity of their GUIs and menu systems. I noticed only one small transgression with regard to the GA4063 Analyser, when the File Manager is used to copy screen image files saved in its internal flash memory to a USB memory stick plugged into the front-panel socket. During the 'paste' operation, a dialog flashes on the display with all text displayed in Chinese – just slightly baffling to those of us not fluent in it. After a while you get used to it, of course.

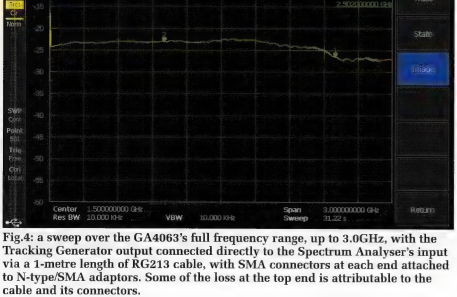


Fig.4: a sweep over the GA4063's full frequency range, up to 3.0GHz, with the Tracking Generator output connected directly to the Spectrum Analyser's input via a 1-metre length of RG213 cable, with SMA connectors at each end attached to N-type/SMA adaptors. Some of the loss at the top end is attributable to the cable and its connectors.

Similarly, I did notice that when you are sweeping with the GA1484, the main frequency display at upper left on the screen remains fixed at the last frequency the generator was set to before sweeping. The start and stop frequencies are displayed in small print over on the right next to their soft buttons. It would be less confusing if the main frequency display changed to either the start or stop frequencies as well.

My only other criticism is that whereas the GA4063 comes complete with a little tool box with some handy cables and adaptors etc, the GA1484 doesn't even come with a single output cable. A bit minimalist . . .

You'll find further information on either of these instruments at the Trio Test & Measurement web site, www.triotest.com.au Or contact them by phone at 1300 853 407. SC

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See Review April 2011

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See Review March 2010

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by K.F. Ibrahim. Published 2003. **$71.00***

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See Review Feb 2004

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By Rodney Champness, VK3UG

Two More Philips Twins: the Australian 123 & Dutch 283A valve receivers

The Australian model 123 and Dutch 283A 5-valve receivers look almost identical from the outside but that's where the similarity ends. Inside the cabinets are two completely different chassis with different valve types and different circuit configurations.

BACK IN 2012, I wrote several articles on a number of John de Haas's twin Philips receivers. In each case, one was from Holland and the other was made in Australia.

Basically, these were sets that looked identical on the outside but their chassis layouts and circuits were completely different. And so it is with the two sets described in this article, the Dutch 283A and its look-alike, the Australian 123. We'll also take a brief look at the 123's country cousin, the model 131, which used the same cabinet as well.

283A and 123 similarities

The 283A and the 123 receivers are housed in virtually identical cabinets measuring 394 x 189 x 251mm (L x D x H). Both sets weigh about 6.7kg and both are designed to operate off an AC mains supply – between 220V and 260V AC in the case of the model 123. By contrast, the 283A can operate from 110-145V AC or from 200-245V AC.

The only things about these sets that appear different when viewed from the front are the knobs and the dial scales. Even then, the general styling is very similar (see above photo).

Another Australian Philips set, the model 131, also looks much the same as these two. However, it's quite different internally to both the 283A and the 123, as it's a dual-wave 5-valve battery-operated receiver with an RF stage. It will not only run off a 745 1.5V battery and two 482 45V batteries in series (or heavy duty versions of these batteries) but can also run off a 6V vibrator pack or even a 32V home lighting plant. Now that's versatile!

Close inspection of the 283A's cabinet shows that the expected Philips badge has been replaced with a badge that says it is a "Siera Aristona". The reason for this is that Philips in Holland made sets that were badged for other organisations, just as happened in Australia. For example, sets manufactured by Philips in Australia could be labelled as "Fleetwood" or "Mullard".

Similarly, Astor sets could be labelled "Airchief", "Peter Pan", "National", "Monarch" or "Pye". And there were

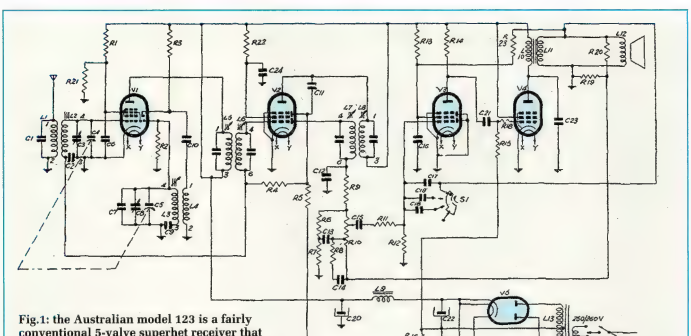


Fig.1: the Australian model 123 is a fairly conventional 5-valve superhet receiver that covers the AM broadcast band only. Valve V1 is the mixer/oscillator, V2 the 1st IF stage & detector, V3 the 1st audio amplifier stage and V4 the audio output stage. V5 is the rectifier.

other manufacturers that did the same thing for small organisations.

Basic specifications

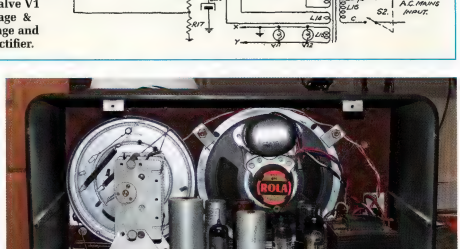
The Dutch 283A is a conventional 5-valve receiver and is similar in some ways to the Australian multi-band table/mantel receivers of the late 1940s and early 1950s. Both the 283A and the 123 have a converter stage, one IF (intermediate frequency) stage, a diode detector, two stages of audio amplification and a dual-diode rectifier.

That's where the circuit similarities end. For starters, the Australian 123 only tunes the broadcast band from 530-1620kHz while the 283A has three AM bands covering 150-433kHz (long wave), 513-1667kHz (broadcast) and 5.77-18.75MHz (shortwave), with bandspread tuning available over part of the shortwave band from 9.23-12.35MHz. This band-spreading was designed to make it easy to tune the 25-metre and 30-metre international shortwave broadcasting bands.

Model 123 circuit details

The 123 has a few circuit refinements that make is just that little bit better than most 5-valve receivers of the era. Fig.1 shows the circuit details.

Starting at the left, the primary winding of the antenna coil is tuned to resonate just below the broadcast band.

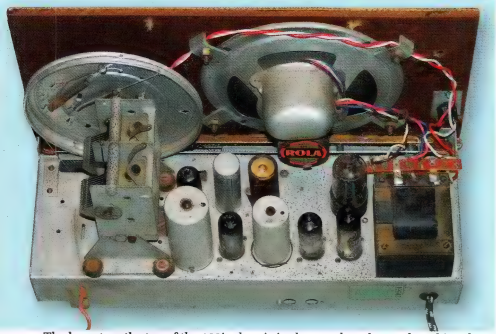


This is the view inside the model 123. The valves are all readily accessible and the chassis can be easily removed from the cabinet for servicing.

This technique boosts the performance, particularly at the low-frequency end of the tuning range, and was necessary to get the best performance out of antennas that were less than 10 metres long. By the early 1950s, customers had become lazy when it came to putting up good outside antennas, preferring shorter indoor antennas instead, so the manufacturers employed this technique to get around the problem.

The secondary winding of the antenna coil is tuned across the broadcast band by one section of the tuning capacitor (C4) and the resulting signal applied to the signal grid of V1, a 6AN7 converter valve. The local oscillator includes V1, coils L3 & L4, the other section of the tuning gang (C5) and their associated components.

Unlike some sets, no high-tension (HT) voltage is applied to feedback winding L4 of the oscillator coil. There is no particular advantage one way or



The layout on the top of the 123's chassis is clean and uncluttered, making the set easy to service. A sheet of Masonite® hard board is used as a speaker baffle.

the other, although the method used in the 123 means that there is no voltage stress across the windings or to earth.

The oscillator tunes from around 985-2075kHz. The resulting 455kHz IF (intermediate frequency) from the converter stage is fed through the first IF transformer and amplified by V2, a 6N8. Its output is in turn fed to the second IF transformer and the resulting signal then fed to V2's detector diode (the lower one in the diagram).

From there, the detected audio is fed to the grid of V3, another 6N8, via an RC network that also includes the volume control (R10). V3 acts as the first audio amplifier stage and its output in turn is fed to V4, a 6M5 audio output valve. V4 then drives the loudspeaker via a speaker transformer.

Note that there is quite an extensive tone control cum negative feedback circuit in this set. First, resistor R23 provides feedback from the secondary of the speaker transformer to the screen of V3. In addition, R19 & R20 provide feedback to the bottom of the volume control

C17, C18 & C19 are switched into circuit by S1 and, together with R12, form the tone control circuit. This circuit feeds signal back to the grid of V3, depending on the capacitor selected. And finally, R6, R7, R8, C13 & C14 form a loudness control in concert with R10. Together, these parts ensure that the set has good "tonal qualities" and minimal distortion.

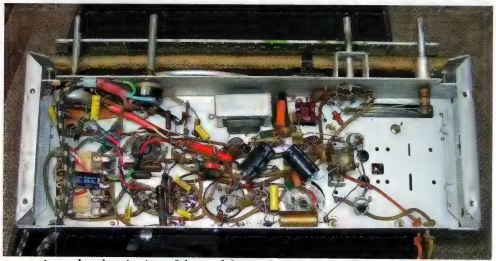
The power supply uses a conventional mains transformer, with V5 (6X5GT) functioning as a full-wave rectifier. Resistors R16 & R17 form a voltage divider and provide negative back bias to V1, V2 & V4.

In operation, the IF signal level at V2's plate can be quite high, particularly when the set is tuned to strong local stations. This signal is applied to the second diode in V2 via C11 and a substantial AGC (automatic gain control) voltage is obtained once the delay on the AGC line has been overcome.

The AGC system is designed to cater for both very strong signals and quite weak ones. No AGC signal is applied to the controlled stages until a moderate strength signal is received, which means that the maximum sensitivity of the receiver is maintained for weaker signals.

Because there is only one audio amplifier stage in 4-valve receivers, they naturally need to have a higher audio level out of the detector than 5-valve sets. This is usually achieved by manipulating the AGC system circuitry. However, this set has a relatively low audio output level from the detector and so a pentode first audio stage is used in lieu of a triode to achieve greater gain.

The end result is a very satisfying performance that's much better than from 4-valve sets. Note that the voltage divider formed by R1 and R21 maintains the screen voltage on the 6AN7 close to a predetermined level, set to achieve optimum performance with the AGC voltage applied to the signal grid.



An under-chassis view of the model 123 after restoration. Only a few parts (mainly electrolytic capacitors) required replacement to get the receiver working again.

Dutch 283A circuit details

Fig.2 shows the circuit details for the Dutch 283A receiver. Once again, it's a 5-valve superhet design but being a multi-band receiver, it's more complicated than the Australian model 123.

As can be seen, the input circuitry is quite different to the 123's. As previously stated, it has four switched bands which tune long-wave, medium-wave (broadcast) and shortwave, with a switchable sub-band so that only a portion of the shortwave band is tuned (ie, for band-spread tuning).

A series-tuned trap consisting of

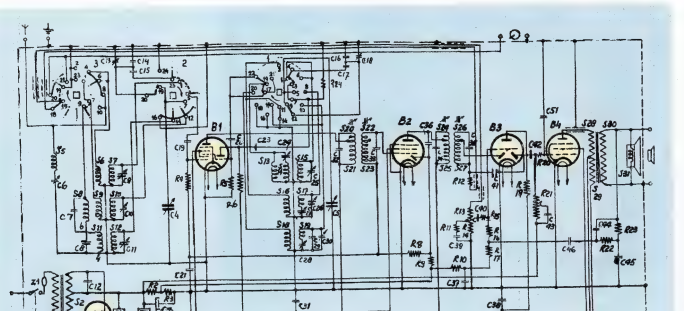


Fig.2: the Dutch 283A receiver is also a 5-valve superhet but is more complicated than the model 123 since it also covers the long-wave and shortwave bands, with a switchable sub-band on shortwave.

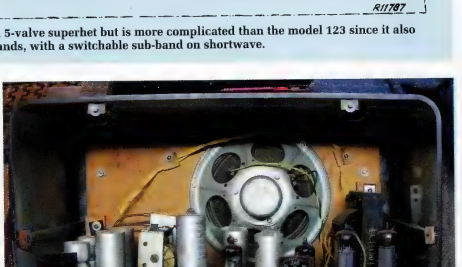
S5 and C6 on the 452kHz IF is connected between the antenna and earth on all bands. This minimises signal breakthrough by stations at the high-frequency end of the long-wave band and is necessary because these stations operate at frequencies close to the IF (down to a minimum of just 19kHz away).

A multi-position switch selects the relevant antenna coil and has an additional position that connects the audio amplifier section to the record player input socket. This socket is shown at the top right of the circuit.

The mixer/oscillator circuit is conventional but because the 283A is a multi-band receiver, the antenna and converter circuits are considerably more complex than in the 123. Valve B1 is an ECH42 and this functions as the converter. Its characteristics are similar to a 6AN7's but it uses the European 8-pin miniature Rimlock base.

In fact, all valves in this set use the Rimlock base which is quite different to the Noval 9-pin base commonly used in Australia.

The 452kHz IF from the converter stage (B1) is applied to the first IF transformer, designated on the circuit as S20, S21, S22 & S23. Its output is in turn fed to B2, an EAF42 valve. This valve has a slightly lower gain than the 6N8 used in the Australian 123 and has only one diode in the envelope.



The Dutch 283A is notably more cluttered inside the case than the model 123, although the valves are still all readily accessible.

B2 amplifies the IF signal and then applies it to the second IF transformer (S24-S27).

The output from the second IF transformer is in turn fed to the diode detector in B3, an EBC41 duo-diode triode. This valve is equivalent to a 6BD7/6BD7A.

From there, the detected audio signal is routed back to the wave-change switch (top left of Fig.2) which selects between it and the record player input. It is then fed back to volume control R13/R14 and then to the grid of B3 via C40 & R15.

B3 amplifies the audio signal and in turn drives audio output valve B4, an EL41 which is equivalent to a 6M5. B4

Most of the parts in the 283A can be accessed with the chassis partially removed from the cabinet. Removing it completely is a lot of work and risks damage to the complicated dial-drive mechanism.

then drives the speaker via an audio output transformer.

Note that the audio wiring to and from the wave-change switch is shielded. This is good practice as it minimises hum in the audio signal.

The lead from B4's plate to the speaker transformer is also shielded, a precaution that's normally considered unnecessary. In this case though, a shielded lead has probably been used to prevent any IF signal that may still present in the output of this valve from being radiated. In addition, this shielded lead also acts as a capacitor (probably 10-15pF) which partially shunts any IF signal to earth.

Note the network connected to B4's grid, consisting of R20 (47kΩ) and C51 (47pF). This network attenuates the IF signal by more than 10dB. In fact, I commonly use this same network configuration on many of the sets that come across my bench if they exhibit excessive IF signal levels in the audio output stage.

The audio negative feedback circuit is less complex than that used on the 123. It consists of an RC network connected the output of the speaker transformer and the grid circuit of B3.

The power supply is again conventional and uses a transformer with a tapped primary so that a wide range of AC mains voltages can be catered for. There is also a fuse in the input to protect the set should something go seriously wrong in the receiver, a feature lacking in the Australian 123.

Valve B5 functions as a full-wave rectifier and the resulting HT voltage is filtered using C1 and C2. Back bias is developed across resistors R2 and R3, while resistor R1 separates the two filter capacitors.

Note that R1 is also connected across one half of the speaker transformer primary, so that this section of the transformer acts as a power choke. This is a great idea provided the phasing of the winding is correct to provide optimum ripple (hum) cancellation in the speaker transformer secondary winding.

The rectifier valve (B5) is a directly-heated type with a 4V heater. There is no equivalent type that was used in Australia. If it ever required replacement, then an indirectly-heated rectifier such as a 6V4 could be substituted with a few modifications. These would involve swapping the socket to a 9-pin miniature type, connecting the 6V4's heater wiring to the 6.3V winding and leaving the 4V winding with no load.

One unusual component in the power supply is capacitor C12 (22nF). This has been included to reduce any interference being fed into the receiver via the mains and then radiated into the antenna circuit. It also acts to suppress interference generated by the rectifier diodes.

Dial drive systems

Dial drives have often caused restorers more headaches than all other problems within a set. Generally, I don't have much trouble with restringing dial drives but even I will not press my luck with some European sets – they can be a nightmare to fix if something goes wrong.

The 283A falls into the latter category. It has a dial-drive that isn't that easy to work on and is not one that I would really want to tackle. It's certainly much more complicated that the dial-drive mechanism on the Philips 123.

In practice, the 283A can be satisfactorily serviced with the chassis only partly removed from the cabinet. Removing it completely is simply too much work and risks damage. Fortunately, the dial-drive system in this particular set was intact and didn't require any work during the restoration.

By contrast, the model 123's chas-

A rear view of the Dutch 283A with the back cover in place. The unit has inputs for a turntable and also features external loudspeaker terminals.

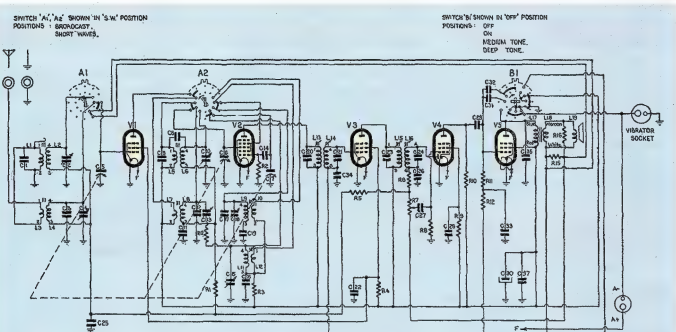


Fig.3: the Australian model 131 is a 5-valve battery-operated superhet that can also be powered from a 6V vibrator or a 32V DC lighting plant. It's housed in the same cabinet as the 123 and 283A receivers.

sis was completely removed from its cabinet during the restoration of that set. It's a fairly simply procedure and the dial-drive was easy to repair.

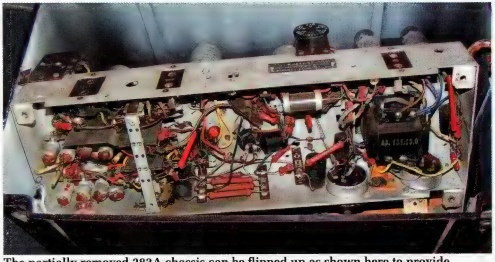
The model 131

Externally, the Australian model 131 looks the same as the other two but it's really quite different. As mentioned earlier, it can be operated from batteries, a 6V vibrator or 32V DC lighting plant.

Fig.3 shows the circuit of the model 131. It uses miniature 7-pin 1.5V battery valves, the line up being 1T4, 1R5, 1T4, 1S5 & 3V4. It's a dual-wave receiver, covering both the broadcast band and the 6018MHz shortwave band.

The model 131 is also a 5-valve receiver but unlike the other two sets, there's no rectifier and it features an RF stage. This gives it greater sensitivity, making it suitable for use in remote rural environments. The performance of the small battery valves is not as good as those used in mains-powered sets, although a 5-valve battery set still performs slightly better than a 5-valve mains operated receiver. That's because a 5-valve battery set has five amplifying stages compared to just four for a mains-operated set, since the fifth valve in the latter is the rectifier.

One advantage of 1.5V battery-operated valves is that they use a lot less power than conventional valves; around 1.8W total for the 131 compared to 45W for the 283A.



The partially removed 283A chassis can be flipped up as shown here to provide access to the under-chassis parts. It has a lot more parts than the model 123.

Summary

Despite being visually similar, the Australian 123 and Dutch 283A receivers are very different to each other when it comes to their chassis design. Both would compare well with each other as far as performance is concerned but the Dutch Philips has the advantage that it can also cover the long-wave and shortwave bands (as well as the traditional broadcast band).

On the other hand, when it comes to servicing or restoration, the Australian set is by far the easier to work on. Many European radio manufacturers, not just Philips, seemed to delight in making their sets difficult and complex to service, although the model 283A isn't too bad in this regard except for the dial-drive mechanism.

In fact, dial-drive systems are one area where European manufacturers have excelled in making something that could be simple into a mechanical nightmare. SC

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INTELLIGENT REMOTE-CONTROLLED DIMMER	APR 2009	10104091	$10.00
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6-DIGIT GPS CLOCK DRIVER	JUNE 2009	07106091	**$20.00**
UHF ROLLING CODE TX	AUG 2009	15008091	$10.00
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6-DIGIT GPS CLOCK AUTODIM ADD-ON	SEPT 2009	04206091	**$5.00**
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TOSLINK TO S/PDIF/COAX CONVERTER	OCT 2010	01210102	$10.00
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RUDDER INDICATOR FOR POWER BOATS (4 PCBs)	JULY 2011	20107111-4	$80 per set
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RESISTANCE DECADE BOX PANEL/LID	APR 2012	04104122	$20.00
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Replacing incandescent lamps with LEDs

Replacing incandescent globes with LED lights in modern cars often causes the sensing circuit (usually built into the Body Control Module) to indicate that a globe is blown ("lamp failure warning"). The common way to overcome this "lamp failure warning" is to put a load resistor across one of the LED lights (ie, in parallel), typically one only resistor per circuit; therefore one in the parking light circuit and one in the brake light circuit.

The idea is to simulate the load of one or two incandescent lamps (typically 21W each) and therefore the load resistor is usually 4.7Ω 50W. However, a large amount of heat is dissipated by the resistor which gets very hot.

So is there a simple current-limiting diode circuit that can limit the current to say 4A (at 12V) and not produce as much heat through power dissipation? I'm thinking about clamping rather than resisting current flow using a power Mosfet or IGBT. (G. L., via email).

● Unfortunately, any load that simulates a lamp filament will require a current flow. So whether it is a resistor or partially conducting Mosfet, there will be power dissipation. The solution to the dissipation problem for brake lights was described in the July 2010 Circuit Notebook pages.

For other lights, you can minimise power dissipation by selecting close to the minimum current required to ensure there is no lamp failure warning. The use of resistors is OK if the power rating has a good safety margin and the resistors are positioned so that they can dissipate heat safely.

Two options to monitor fuel economy

I have found that the fuel economy of my car improves significantly with good driving practices (as you would expect) but that it is very difficult to achieve this consistently. My car does not have a trip computer fitted so I have no way of monitoring the instantaneous fuel consumption.

It would be very useful to have an instantaneous indicator of fuel usage that can be fitted easily to modern cars with fuel injection, ECUs etc.

Have you ever published a design for a car economy meter, eg, one that varies the brightness of a LED or similar in accordance with the load on the engine? I remember years ago the Chrysler Valiant had a light mounted on the driver's side front guard that was visible from the driver's seat and that glowed according to how hard the car was accelerating.

If SILICON CHIP has not produced a suitable design, would one that is simple, cheap and easy to build and install be feasible? ULP has just reached $1.65/litre here and I suspect that quite a few motorists would be interested in a way of increasing their car's fuel economy.

Perhaps it could be based on the output from the MAP sensor or ECU

Difficulties With Frequency To Voltage Conversion

In the Circuit Notebook pages of the June 2010 issue, you have an article on Frequency-to-Voltage and Voltage-to-Frequency Converters, written by John Clarke. Both are to be used with the Voltage Interceptor (SILICON CHIP, December 2009), also by John Clarke.

I have spent well over a week trying to get the Interceptor circuit to work as per the article and after two attempts at building it (the second time very carefully to ensure I had built it exactly as per the diagrams), I sent the article to an electronics designer friend I know in Japan. He replied saying that pin 5 on IC2 (4046B) should be earthed.

I also had to fit an extra 100nF capacitor in series between pins 6 & 7 to get the "Frequency Out" high enough to suit my motor's (Lexus V8 1UZFE) Mass Air Flow (MAF) requirements of up to 1kHz.

I'm now having a lot of trouble trying to get the Frequency-to-Voltage Converter circuit to put out a voltage signal suitable to coincide with the requirements needed to equal the Frequency-to-Voltage output, as trimpot VR1 does not adjust the output voltage range (as suggested in the article) but instead just 'caps' the voltage to a set voltage (in this case 4V, as suggested in article) which of course makes it impossible to get a linear output out of the Voltage-to-Frequency Converter.

Can you tell me if anyone actually built and tested this circuit before you published it and if so, can anyone please tell me how to get it working correctly? (G. G., Hastings, NZ).

● The design was for use with the Karmin Vortex air-flow meter. The frequency range will differ with different air-flow meters and the circuit was shown as a guide as to how to convert from frequency to voltage and then voltage to frequency. The design was proven by a reader of SILICON CHIP who had requested such a circuit.

Based on your need to use a nominal 47nF capacitor for C1 (two 100nF in series) instead of 100nF, the 10nF capacitor at pin 2 of IC1 would probably need to be reduced to 4.7nF. This would allow the output voltage to swing without it clipping at 4V with a 1kHz input. In other words, if the voltage output clips at 4V, then the capacitor will need to be reduced to lower the voltage.

It may be easier to adjust the output range of the frequency-to-voltage converter before then attempting to set up the voltage-to-frequency converter.

USB/SD Card Addition To The Studio Series Stereo Preamplifier

I have been enjoying CD music via the Studio Series Stereo Preamplifier (SSSP) and Classic D amplifier I recently built but I would also like to play music from an SD card.

I started looking through my back issues of Silicon Chip and found the article on the Tenda MP3 modules by Ross Tester in the January 2012 issue. As a result, I purchased a Tenda TD898 module from the Silicon Chip shop. I removed the headphone amplifier from the SSSP, cut an appropriate slot in the front panel and fitted the TD898.

I mounted the IR receiver into a hole drilled in the TD898 front panel just to the left of the 'Audio In' socket. I mounted a piece of Veroboard with audio out and power connectors on brackets fixed under the TD898 circuit board mounting screws.

The TD898 works well (apart from some idiosyncrasies to do with its controls) except that with full volume, its signal level into the SSSP is lower than that from the CD player, necessitating a change in volume when switching from one input to the other. I thought about boosting the TD898 output using the Champion preamp with its two outputs separated and connected to two trimpots to make a one-off level adjustment. However, I wondered if an easier method might be to isolate the SSSP Inputs 2-5 from Input 1 (Tape) and use a couple of resistors as a voltage divider to reduce the input levels for Inputs 2-5.

This would require some modifications to the SSSP preamp board but I'm not sure if such a voltage divider is practical and if it is, what values to use. Could you please advise me? (D. H., via email).

● It's easy to add in the voltage dividers for each channel on the inputs you need to reduce in level. The tracks from the left and right output pins on each RCA socket that lead to the relay are cut and a resistor added between these two points instead. A second resistor connects from each relay input to the ground track. The resistors are best soldered to the RCA socket and relay pins under the PCB.

The voltage divider should have a total resistance of about 10kΩ. So if you want to attenuate by a factor of two, for example, use two 4.7kΩ resistors. You could use a 10kΩ trimpot instead, with the wiper to the relay connection and the outside resistance connections to the RCA output and ground.

on a modern car. Ideally it should be able to be fitted without interfering with the vehicle wiring or equipment to the extent that there is a risk of voiding the warranty. (I. P., Fullarton, SA).

● We published a GPS Car Computer in January & February 2010 which provided relative fuel economy readings. It monitors the car's fuel injector duty cycle and then displays relative fuel economy as a bargraph. You can access the article at www.siliconchip.com.au

A kit is available from Altronics (Cat. K1133). Alternatively, if your car has an OBD2 (on-board diagnostics) socket, you might want to consider a head-up display which displays speed, instantaneous fuel economy in litres/100km and has other functions. We featured an article on this in the September 2013 issue.

Extended delay for Power Tool Soft Starter

I have a question about the Soft Starter For Power Tools (Silicon Chip, July 2012). We are looking to get something along this line where the soft start extends to about 5-10 seconds.

Would this kit be upgradable to achieve that? (B. A., Melrose Park, NSW).

● There should not be any problem with extending the relay activation time delay to be as long as you want (within reason); it's simply a matter of increasing the value of the 220nF capacitor. For a 5-10s delay you would need a few microfarads which means the best choices will be multi-layer ceramic or electrolytic; either should be fine. Just watch the orientation if you use an electro (positive lead to +12V rail).

Ceramic capacitors have a better lifespan but commonly available through-hole parts go up to about 2.2μF. Having said that, you can get higher values and these are to be preferred over electros which tend to have a worse tolerance spread. Either way, they will need to have a voltage rating of 16V or more.

Depending on the load current, after 5-10 seconds, the NTC thermistor resistance will probably have dropped to a very low level anyway. That does mean less voltage across the relay contacts when they switch which is a good thing.

Beefing up the 230VAC 10A speed controller

I have a problem with my 230VAC 10A Motor Speed Controller (Silicon Chip, May 2009). It has done about 12 hours of work powering an 800W grinder to use as a polisher. It no longer slows my grinder down but drives it at full noise regardless of any of the adjustment settings inside or outside its metal box. The 470Ω snubber resistor has been getting really hot and Q1 seems to be short circuit.

Is it worth replacing Q1 or will I only get another 12 hours out of it? If so, who sells these IGBT components? Am I better off ditching it and buying a Variac as I fear my needs may be a bit hard on it? (E. B., Carters Beach, NZ).

● Possibly you are right in saying that the original type of IGBT may blow again when replaced when powering the 800W grinder. element14 sell IGBTs (NZ.element14.com) and you could used a higher rated IGBT more suited for your application.

The snubber resistor could be changed to 2.2kΩ 1W to prevent it overheating.

Wien bridge oscillators are obsolete

Over many years, I have built several Wien Bridge oscillators but as time wore on, most of them simply did not do the job I wanted them to do because their parts simply wore out and requirements began to increase. Most oscillators used an incandescent lamp to stabilise them such as a 'grain of wheat lamp' or something more

suitable. Unfortunately, incandescent lamps are becoming hard to get because LEDs have mostly taken over.

There is a LED/LDR arrangement that has a limited frequency range which I tried with a certain amount of success but the unit is not exactly what is required. If you look at www.sound.westhost.com there is a section on sinewave oscillators and the chap who runs it says that a DIY sinewave oscillator is not easy to build any more because of the lack of good quality components. In this section on sinewave oscillators, he describes most of the popular configurations of variable-frequency sinewave oscillators but most of the designs lack one feature or another. Browsing the internet shows much the same thing.

He seems to think that most variable sinewave oscillations in the near future will be of the digital variety, some of which also have their own problems. The digital circuitry could also end up being expensive to build because more costly ICs need to be used to get a good result.

Over the last few weeks, I have been experimenting by lashing up various variable sinewave oscillators and have found that the best of them appear to use ±12V or ±15V power supplies, preferably low noise. The oscillator I built up was from a circuit on the internet that wasn't variable but used a ±15V power supply. It also used a low-noise IC, together with a complimentary symmetry output stage.

On switch on, there was a small amplitude bounce and my counter said it

Using the Champion Amplifier With Headphones

Would the Champion Audio Amplifier module (SILICON CHIP, January 2013) be suitable for earphones and would there be any modifications needed? (G. P, via email).

● We assume that by "earphones" you are talking about earbud-type headphones rather than the very sensitive, high-impedance earphones which were commonly used with crystal radio sets and such. The Champion certainly should be able to drive ear buds although with a single board, you would have to drive them in parallel and thus would only get mono sound.

Depending on the signal source, you will probably want to knock back the gain quite substantially or else the result will be very loud, with lots of noise. You may also want to put a resistor in series with the ear buds (a few dozen ohms, say) to further limit the maximum volume level.

To reduce the gain, omit the 1kΩ resistors connected to pins 2 & 6 of IC1. Be careful to start out initially with the volume at minimum and check that the volume control isn't too sensitive; if it is, increase the 2.2kΩ resistors from pins 1 & 7 of IC1 to reduce the maximum volume.

We have published other designs specifically for headphones/ear buds such as the High-Performance Stereo Headphone Amplifier in September/October 2011, the Portable Headphone Amplifier For MP3 Players in April 2011 and the Studio Series Stereo Headphone Amplifier in November 2005.

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Battery Confusion in Lump-In-The-Coax Mixer

I have a question about the LiPo charger included in the "Lump-In-The Coax Mixer" (June 2013). The input for the charger seems to be 5V but the LiPo battery is shown as 9V.

How can a 9V battery be charged from a 5V source without a "buck-boost" somewhere in the line? Surely the LiPo battery is 3.6V or 3.7V or is it intended that the input be, say, 12V for charging the 9V battery?

- The "Lump-In-The-Coax" mixer gives the option to use a standard 9V battery or a lithium-polymer. You are right that if using a Li-Po, it is a single cell with a nominal voltage of 3.6V or 3.7V and thus can be charged from a 5V supply using a linear regulator (the BQ2057 plus PNP transistor Q2).

If a 9V battery is used, REG1 is fitted and this drops the supply voltage to the circuit to 5V, as 9V could damage IC1 & IC2. The same connector (BATT1) is used for either the 9V battery or Li-Po but only one type should be used, depending on how the circuit is configured.

There is no provision for charging a 9V battery since the advantage of the 9V option is that you can just use standard disposable 9V alkaline/dry cells. If you want to run the mixer from a rechargeable battery, a single cell Li-Po is the way to go (and it will probably fit in the specified case too).

easily reached 100kHz. The sinewave looked clean and well-shaped but of course you need a distortion analyser to really tell how much distortion the instrument is producing.

I tried 6V, 12V and 18V lamps and some 6V lamps in series and on adjusting the 20-turn pot, they all worked well with varying degrees of waveform bounce. It seems as though the lamp does matter, just as the chap says at the above mentioned website. There was also a website which went quite deeply into the kind of incandescent lamp one should use; unfortunately these are unavailable today.

It could be that I'll have to look for a decent digital variable-frequency sinewave oscillator. When I build sinewave oscillators, I've usually included buffer circuits so I can connect a frequency counter or a CRO to the oscillator without ill effects. Connecting external instruments can cause earth loops to form with unpleasant results.

I've also tested quite a few dual-gang pots and found them badly out of tolerance between each section, which is expected. It seems as though nobody makes accurate pots any more. The better the pot, the less bounce there is providing you can also get the right lamp.

I've thought of buying a lot of cheaper single pots, testing them and then joining the best two together with a bracket in order to get a better matched pair. I'll do a bit more research before I go down that path.

I've looked through the many SILICON CHIP magazines I have to hand and it seems to be a fairly long time ago that you have actually produced a variable-frequency sinewave oscillator circuit. Making it also sweep over the audio range would also be useful. In this case, an IC generator chip is sometimes used (there are quite a few circuits on the web) but most of the circuits lack very low distortion levels. These particular instruments can be useful to a certain extent but to produce a really good instrument would probably take some doing. (G. K., via email).

- You have pretty much covered all the pros and con of Wien Bridge oscillators and that is why we have not published a more recent design. Have a look at our Digital Audio Signal Generator from the March - June 2010 issues. This gives very low distortion, very good envelope stability, has sine, square, triangle and sawtooth waveforms, and can be swept over a wide range etc.

Difficulties in adjusting solar panel controller

I have constructed the Solar Lighting Controller from the May 2010 issue. With 14.4V from the panel, I have 12.98V charge; at 15.7 V from the panel, it is 13.04V and at 17.4V from the panel, I get 13.3V. I am unable to achieve the 14.4V cut-off point despite setting VR1 to 5V and VR2 to a battery voltage of (13.23 x 0.3125) = 4.3V. Can you offer any comment?

Are there any plans for more solar projects such as an inverter rated at between 1-2kW? I appreciate your assistance and the effort to produce such a good magazine. (B. M., Auckland, NZ).

- The battery voltage setting at TP2, as set by VR2, should be the measured battery voltage (in your case the 13.23V) multiplied by 0.3125. That's 4.134V. Using 4.3V instead will lower the charge cut-off voltage.

Actual cut-off voltage is dependent

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on temperature and the cut-off voltage will vary if the temperature is not 20°C. That is whenever the compensation (VR3) is set to above 0mV/°C.

Otherwise, there may be some other problem with the charger. Check that the components for IC2a's input voltage divider are correct and also check IC2b's current measuring components. If these cannot provide the correct solar panel voltage and current flow values to IC1, then the MPPT charging will not operate.

If the cut-off voltage is still too low, try adjusting VR2 to get the required cut-off value.

Birds to sing on demand

I have previously discussed with friends how nice it would be to be awoken in the morning by the sound of something gentle such as birds singing instead of the harsh beeping of a digital alarm clock. Is there some way to get the PC Birdies, featured in the August 2013 issue to sing on demand? (T. U., Maleny, Qld).

- The birds sounds will start if the

continued on page 104

Notes & Errata

Automatic Car Headlight Controller, October 2013: there should be seven 1µF multilayer capacitors in the parts list, not six. Also, the three 2-pin headers are for jumpers JP1-JP3; there is no JP4.

2.5GHz 12-Digit Frequency Counter, December 2012 - January 2013: excessive 'bobble' on the least significant digit of the counter's display when measuring low frequencies has been discovered. This is due to the first counting decade counter, IC14, not being properly reset prior to making each count.

The cure is to insert a few lines of code into the firmware. A revised 'Version 1.2' firmware (both source code and hex code) is available for free download on the SILICON CHIP website.

IR-to-UHF Converter, July 2103: the 100Ω resistor at pin 1 of OPTO1 will need to be reduced if the optocoupler doesn't work. A value between 22Ω and 47Ω should suffice.

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. . . continued from page 103

LDR resistance is brought from an initial high value (when in darkness) to a low value (when exposed to daylight). So that effect can be simulated using a reed relay that closes contacts across pins 5 & 2 of IC1 when the bird sound is required to start.

The LDR should be removed from circuit.

Alternatively, applying power will start bird sounds after a short 5-second delay provided the LDR is exposed to daylight or shorted out.

How to filter a modified sinewave inverter

I had an idea for smoothing the "modified" sinewave from a cheap 12V to 230VAC inverter but I'm unable test to the idea right now as I don't have access to an oscilloscope.

Could you simply add a large suitably-rated iron-core choke in series with the secondary 230VAC circuit (eg, use either the primary or secondary winding of an iron-core transformer)? Would this round off all the sharp corners of the modified waveform? I could see noise emanating from the transformer as a potential issue. (J.K., Emerald, Qld).

● The switching frequency of a modified sinewave inverter is only 50Hz. If you were to filter out the high frequency components for a sinewave output you would need bulky components that would reduce the overall efficiency from the inverter. You will be restricted to less of the available inverter power due to the removal of the 50Hz harmonics by the filter components. In a real filter, there will also be resistive power losses that will generate heat.

Pure sinewave inverters develop the 50Hz sinewave at a much higher switching frequency than the 50Hz of a modified sinewave inverter and so the filter components are smaller and more efficient. SC

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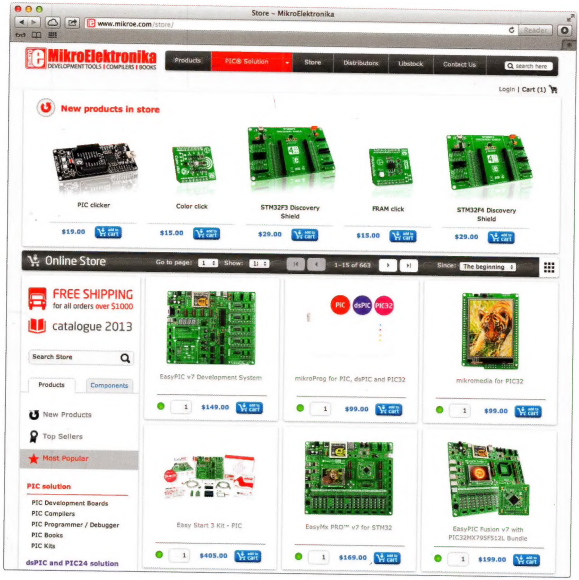

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